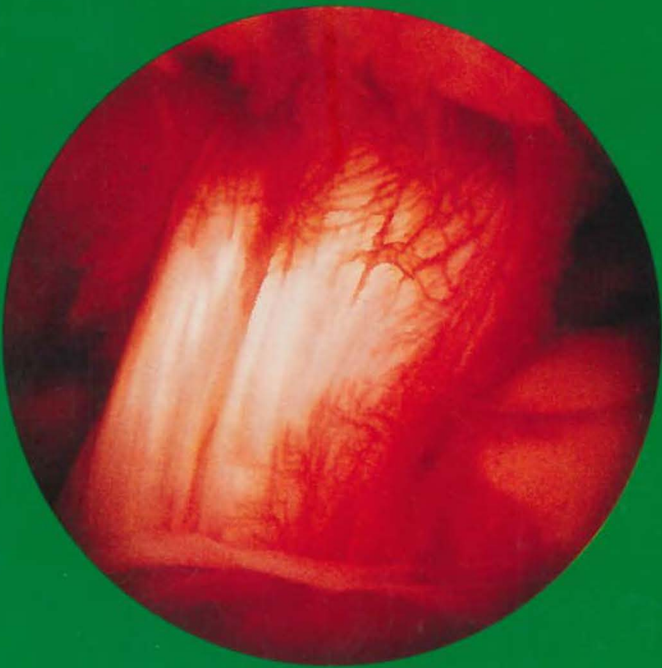
Chronic posttraumatic Instability of the knee. A diagnostic study

Gerding, Johannes Constantijn

Chronic posttraumatic

Instability of the knee

A diagnostic study



J.C. Gerding

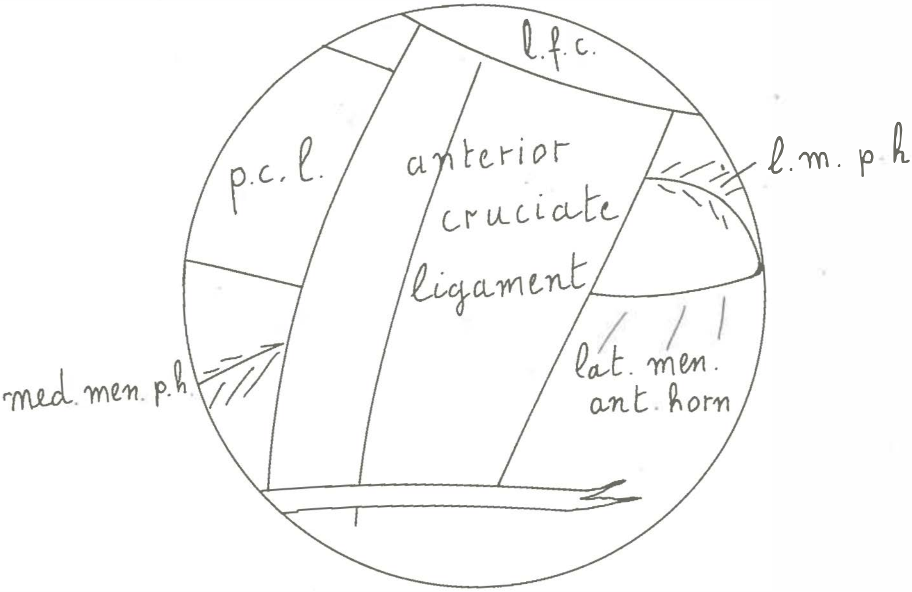


photo H.R. Eikelaar

STELLINGEN

1.

Ten onrechte wordt alleen de achterste kruisband als centrale stabilisator van de knie beschouwd.

Hughston J. C., e.a., J.B.J.S. vol. 58A, p 159 en p 173 (1976).

2.

Bij de patient met een getransplanteerde nier dient de toediening van corticosteroïden in de postoperatieve phase zodanig marginaal te zijn dat de kans op femurkopnecrose minimaal wordt.

3.

Een gering ladenverschijnsel naar achteren is niet bewijzend voor een achterste kruisbandlaesie.

4.

De toepassing van koolstofdraden opent perspectieven voor de behandeling van gescheurde kruisbanden.

5.

Het is onlogisch de laparotomiewond na vaststelling van een etterige buikvliesontsteking te sluiten.

6.

Als behandeling van het carpale tunnel syndroom verdient de benadering volgens Tubiana de voorkeur.

Kuhlmann N., e.a., Rev. Chir. orthop. T. 64, p 59 (1978).

7.

Alleen met inzicht in eigen beperkingen kan een Arts zijn werk verantwoord uitvoeren.

8.

Het is te verwachten dat het quantitatief onderzoek van farmaca in het bloed een hoge vlucht zal nemen.

9.

Groeistoornissen ontstaan na epiphysiolysisfracturen dienen meestal behandeld te worden door excisie van de beenbrug en interpositie van een vrij vettransplantaat.

10.

Ten onrechte wordt een patient met een lumbale spinale stenose vaak psychosociale deficientie verweten.

11.

Een scheur van de voorste kruisband, als geïsoleerd letsel, is een relatief frequent voorkomende afwijking.

12.

Bij pijnklachten die als directe oorzaak hebben een lunatomalacie heeft de behandeling, waarbij het os lunatum wordt vervangen door een silastic prothese, de voorkeur.

13.

In 1985 zal de Nederlandse jeugd bedrevener zijn in het skiën dan in het schaatsen.

Stellingen behorende bij: Chronic posttraumatic instability of the knee,

J. C. Gerding

RIJKSUNIVERSITEIT TE GRONINGEN

CHRONIC POSTTRAUMATIC INSTABILITY OF THE KNEE

A diagnostic study

PROEFSCHRIFT

ter verkrijging van het doctoraat in de Geneeskunde
aan de Rijksuniversiteit te Groningen
op gezag van de Rector Magnificus Dr. J. Borgman
in het openbaar te verdedigen op woensdag 7 maart 1979
des namiddags te 4 uur

door

JOHANNES CONSTANTIJN GERDING
geboren te Amsterdam

Drukkerij Westerbaan en Westerhuis b.v., Leeuwarden

PROMOTOR: PROF. DR. H.K.L. NIELSEN
CO-REFERENT: DR. C.J.P. THIJN
CO-REFERENT: DR. P.F.A. MARTINEZ-MARTINEZ

Aan Marica
Aan mijn ouders

De in dit proefschrift beschreven patiënten werden behandeld in de afdeling Orthopaedie (hoofd: Prof. dr. M.J. Kingma, Prof. dr. H.K.L. Nielsen) van de Kliniek voor Heelkunde (hoofd: Prof. dr. P.J. Kuijjer) van het Academisch Ziekenhuis te Groningen.
De anatomische- en mechanische studies werden verricht in het laboratorium voor anatomie en embrylogie ('hoofd: Prof. dr. A.G. de Wilde) der Rijksuniversiteit te Groningen.
Het kniestressapparaat werd gemaakt door de techynische dienst van het Academisch Ziekenhuis te Groningen.
De foto's werden vervaardigd door de Universitaire Fotodienst, de heren M.J. Martens, A. Huiser en Th. Hersevoort van de afdeling Medische Fotografie en de heer H. van der Zwaag van het Radiologisch Instituut, allen te Groningen.
Mevrouw M. Hermans verzamelde de aangevraagde literatuur.
De dames J. Redeker-de Boer, U. Bosma en J. Pastoor-Scholten verzorgden het typewerk.
De heer Th. van Winsen vertaalde het proefschrift in het Engels.

Ten geleide.

Het schrijven van dit proefschrift geeft mij de gelegenheid te bedanken diegenen, die hieraan hebben meegewerkt.

Mijn ouders ben ik ten zeerste dankbaar. Ze vormen de basis van mijn opvoeding en mijn opleiding tot orthopaed.

Hooggeleerde Nielsen, hooggeachte promotor, hooggeachte leermeester, U hebt mij op de meest juiste wijze bijgestaan in de totstandkoming van mijn opleiding en mijn proefschrift.
Ik ben U hiervoor zeer erkentelijk.

Hooggeleerde Kingma, hooggeachte leermeester, U staat aan het begin van mijn keuze tot orthopaed, mijn opleiding in de orthopaedie en het schrijven van dit proefschrift.
Ik dank U.

Zeer geleerde Martinez-Martinez, Uw kennis van de anatomie en de mechanica van het kniegewricht is groot. Met de juiste toon wees U mij de goede weg.
Uw hulp heb ik zeer op prijs gesteld.

Zeergeleerde Thijn, U combineert wetenschappelijke kennis met inventiviteit en artisticiteit.
Ik dank U voor Uw bijdrage aan dit proefschrift.

Zeergeleerde Eikelaar, beste Harry, jouw ervaring in de arthroscopie is alom bekend. Ik ben je dankbaar voor jouw lessen over de indicatie, interpretatie en techniek van de arthroscopie alsook voor jouw hulp aan dit proefschrift.

Zeergeleerde Carpentier-Alting, beste Menzo, je hebt mij begeleid in de anatomie en de mechanica van het kniegewricht. Dat wij hiernaast vrienden werden is puur toeval.
Ik dank je echter voor beide.

Geleerde Hillen, beste Berend, ik heb kunnen profiteren van jouw kennis van de mechanica van het kniegewricht.
Ik ben je zeer erkentelijk voor jouw medewerking.

Zeer geleerde Van Wachem, beste Ron, jouw hulp bij het wiskundige gedeelte was van grote waarde.
Ik dank je hiervoor.

Waarde collegae assistenten. Ik dank jullie voor de vriendschap, de goede samenwerking en de medewerking aan dit proefschrift.

Lieve Marica, jij hebt gezorgd voor de italiaans artistieke toon van dit proefschrift.
Ik dank je hiervoor ten zeerste.

CONTENTS

CHAPTER I

Introduction

The ever increasing incidence of knee injuries and the often unsatisfactory results obtained by various conservative and operative methods of treatment have prompted efforts to ensure the necessary improvements in the diagnosis of the traumatized knee. One of its components is the diagnosis of lesions of the knee ligaments.

I.1. Data from the literature

The diagnosis of acute lesions of the knee ligaments is described in several orthopaedic textbooks (Helfet, Kingma, Smillie, Wilson). The diagnosis of chronic posttraumatic instability of the knee ligaments has received little attention in these textbooks, but the literature comprises a number of monographs (Burri, Palmer, Ricci, Trillat) and several publications on these problems (Bousquet, Castaing, Dejour, Hughston, Jacobsen, Kennedy, Slocum, Wirth).

I.1.1. Clinical diagnosis

Palmer (1938) published a good survey of the clinical and radiological diagnosis of the unstable knee, both in its acute and in its chronic stage. He also described the features of the clicking knee, more commonly known today as anterolateral rotatory knee instability or anterolateral subluxation.
Slocum (1968) described the clinical features and aetiology of anteromedial rotatory instability of the knee, also known as anteromedial subluxation of the knee.
The French school (Trillat, Ficat and others) specialized in the clinical diagnosis of acute and chronic lesions of the knee ligaments, and in this respect was followed by the German school. The anglo-american schools (Smillie, Hughston and others) focus on the diagnosis of lesions of the posterior cruciate ligament.

I.1.2. Radiological diagnosis

Barth (1898) described the avulsion fracture of the tibial eminence, and related its radiological features to instability of the cruciate ligament. Using negative contrast, Hoffa (1906) visualized the posterior cruciate ligament. Using positive contrast, Lindblom (1934) developed the arthrographic diagnosis of both cruciate ligaments. Kennedy and subsequently Jacobsen perfected radiological stress studies.

I.1.3. Mechanics of the knee

In 1836, the Weber brothers published their ,,Mechanik der menschlichen Gewerkzeuge'' (mechanics of human tools), in which they described the anatomy and function of the knee-joint and the ligaments of the knee.
Braune and Fischer (1887) studied articular movement in test subjects by means of synchronized photography (strobography). They determined the displacement of the centre of gravity of the body weight in relation to the various joints.
Fick (1911) described the displacement of the rotation centre of the knee-joint, and introduced the term evolute for the curve obtained. The kinematics and dynamics of the human joints have taken a wide scope since 1965. Some authors who merit mention in this context are Huson, Maquet, Menschik, Morrison and Paul.
Fick and later others have described the movement of the kneejoint as projected in the sagittal plane. The literature includes no data on the projection of these movements in the frontal plane. The rotatory movement which forms part of this flexion-extension movement (final rotation) was carefully studied by Fick and later by others. With regard to the voluntary rotation of the knee-joint the literature shows a discussion about the localization of the axis of rotation.

I.2. Objective

The objective of this thesis is to present a survey of the diagnostic possibilities in examination of the unstable knee. This is preceded by a discussion of the anatomy and mechanics of the knee-joint. We intend to discuss the results of three studies:
one of a human test subject and two of anatomical specimens. Clinical, radiological and arthroscopic methods of investigation will be discussed each with reference to the literature and to personal observations.
In the conclusion of this study, an attempt will be made to achieve greater clarity with regard to the following questions:

1. What is the value of careful clinical examination in the case of knee instability?
2. What is the value of routine radiological examination in the case of ligament instability?
3. What is the value of arthrography in the case of a cruciate ligament lesion?
4. What is the value of a radiological stress study?
5. What are the social consequences of chronic posttraumatic ligament instability?

I.3. Concept definitions

Knee instability	— Abnormal mobility or movability of the knee-joint as compared with the unaffected knee or with a normally functioning knee-joint.
Ligament instability	— Instability resulting from rupture, avulsion or elongation (due to scar tissue) of a ligament.
Acute ligament instability	— Ligament instability within three weeks of the accident.
Chronic ligament instability	— Ligament instability which is present over a longer period: usually months or years.
Anterior drawer sign	— Excessive anterior mobility of the knee-joint from the neutral position, visible with the knee in flexion.
Posterior drawer sign	— Excessive posterior mobility of the knee-joint from the neutral position, visible with the knee in flexion.
Passive drawer sign	— Abnormal mobility as described above, visible at maximum relaxation of the musculature.
Active drawer sign	— Abnormal mobility as described above, visible upon contraction of certain muscles.
Collateral instability	— Medial or lateral instability without further differentiation.

I.4. Personal observations

Personal observations were made on two groups of patients: one group of 60 patients with a total of 64 clinically unstable knees, submitted to extensive radiological studies, and another group of 231 patients submitted to arthrography and arthroscopy of the knee-joint. Posttraumatic ligament instability was diagnosed in 68 knees (29%) in the latter group. There was some overlapping between the two groups, leaving us with an ultimate total of 87 unstable knees in 83 patients.

Note: The percentages given in this study do not refer to 100 patients but merely serve as guideline.

CHAPTER II

ANATOMY OF THE KNEE

II.1. Introduction

This chapter discusses the anatomy of the knee so far as it is relevant to the stability and movements of the knee-joint. With reference to data from the literature, the following structures are discussed: femur, tibia, patella, menisci, knee capsule, knee ligaments and muscles.

II.2. Osseous and cartilaginous structures

II.2.1. Femur

The femur distally ends in two prominences: the medial and the lateral femoral condyle. These condyles mainly protrude laterally and posteriorly, and show anteroposterior divergence in relation to a sagittal plane extending through the femur. Distally and dorsally they are separated by the deep intercondylar fossa (fossa intercondylaris). On the anterior side there is a shallow furrow lined with cartilage: the intercondylar line (linea intercondylaris). The medial condyle is less broad, shows more marked divergence and extends further distally and posteriorly than the lateral condyle. The anterior, inferior and posterior aspects of each condyle are lined with a layer of articular cartilage which is 2-3 mm thick. The lateral aspects of the condyles show several ridges, elevations and depressions on which the joint capsule, the ligaments and the muscles insert.

II.2.2. Tibia

The proximal part of the tibia has the shape of an inverted pyramid and protrudes posteriorly and laterally. The base of the pyramid is the tibial plateau, and the superior articular surface (facies articularis superior) consists of two articular facets, separated by the intercondylar area (area intercondylaris). These articular facets present themselves as two shallow oval depressions, the longitudinal axis of the lateral depression showing a sagittal and that of the medial depression showing an oblique course, with anteroposterior divergece in relation to the sagittal plane. Medially, the articular surface is convex in all directions, measuring an average of 48,3 cm sagitally and an average of 31,7 cm frontally (see diagram 1). Laterally, the articular surface is concave in the frontal plane and convex in the sagittal plane, with the convexity mostly in the posterior one-third, and measuring an average of 41,6 cm in sagittal and an average of 33,4 cm in frontal direction (see diagram 1). The articular facets are lined with hyaline cartilage which has a thickness of 4-6 mm. the intercondylar area is an irregularly elevated part which, so to speak,

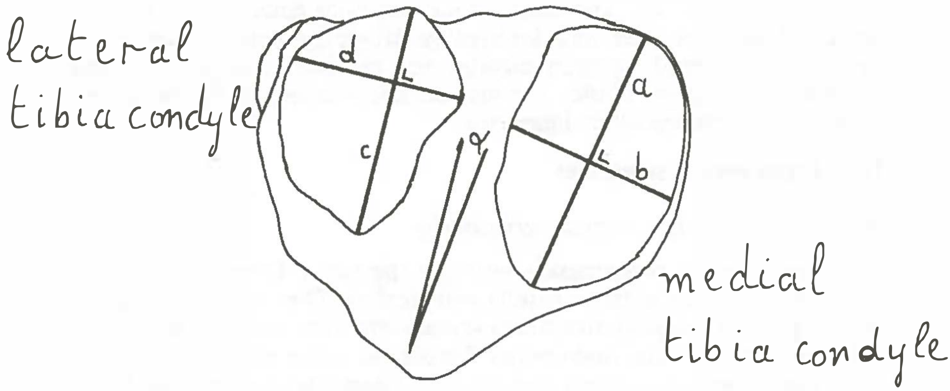


Diagram 1 Ch. II: measurments of the tibial plateau on 10 anatomical specimens
a. is the largest diameter of the medial articular facet in sagital direction. It varied from 42 to 52 mm (average 48, 3 mm).
b. is the largest distance of the medial articular facet perpendicular to a. It varied from 28 to 35 mm (average 31,7 mm).
c. is the largest diameter of the lateral articular facet in sagital direction. It varied from 34 to 45 mm (average 41,6 mm).
d. is the largest distance of the lateral articular facet perpendicular to c. It varied from 31 to 37 mm (average 33,4 mm).
The angle between a and c was directed frontally or dorsally varying from 0° to 10°.

reinforces the articular depression; the highest peaks in this area are the medial and lateral intercondylar tubercles (tubercula intercondylaria). the medial intercondylar tubercle is in a more anterior position than the lateral.

II.2.3. Patella

The patella is a flat, triangular sesamoid bone, with the apex directed distally. The posterior aspect is lined with a layer of hyaline cartilage which is 4-5 mm thick. The remainder of the patella is connected with the extensor apparatus of the knee. The patella, as component of the extensor apparatus, plays an important role in the stabilization of the knee (cf Chapter III).

II.2.4. Menisci

The menisci are annular structures which consist of fibrous cartilage. They are localized between the femoral and tibial condyles and improve the congruence of the articular facets. They are wedge-shaped in cross-section; the base of the wedge lies at the periphery and, on the medial side, is completely in contact with the joint capsule; on the lateral side this contact is only partial. The anterior and posterior ends of both menisci are attached to the intercondylar area by strong ligaments. Small bundles of fibres extend between menisci and cruciate ligaments, uniting them to a functional whole. The menisci are attached to the patella by Pauzat's (meniscopatellar) ligaments.

II.3. Ligamentous structures

II.3.1. Joint capsule (capsula articularis)

The joint capsule encompasses virtually the entire knee-joint, since it connects the femur to tibia, patella and menisci. The capsule consists of two layers: the synovial membrane (membrana synovialis) as inner, and the fibrous membrane (membrana fibrosa) as outer layer. The fibrous layer consist of longitudinal and circular fibres (the longitudinal fibres being more numerous). The thickness is variable according to localization: between menisci and tibia it is thicker than between menisci and femur; and its posterior part is thicker than the anterior part. A number of ligamentous structures on the posterior side ensure further reinforcement of the capsule: oblique popliteal ligament (lig popliteum obliquum) and arcuate popliteal ligament (lig. popliteum arcuatum).

II.3.2. Patellar ligament and patellar retinacula (lig. patellae et retinacula patellae)

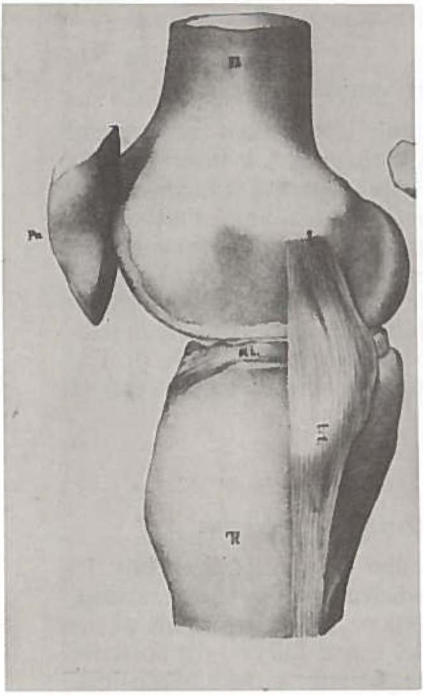
The patellar ligament is a very strong fibrous ligament which has two parts: the superficial part is an extension of the extensor apparatus of the knee, while the deep-seated part attaches the patella to the tibial tuberosity. The patellar retinacula (medial and lateral patellar retinaculum) extend from the upper half of the patella to the tibial condyles. In addition there are transverse bundles of fibres which attach the patella to the femoral condyles (transverse patellar retinacula). With Pauzat's ligaments these retinacula form part of the joint capsule.

II.3.3. Tibial collateral ligament (lig. collaterale tibiale)

This is a broad, flat, triangular and strong structure. Its anterior part extends vertically, is distinctly separated from the joint capsule and consists of fibres of 10-12 cm length. The posterior part extends in oblique posterior direction, unites with the joint capsule and inserts on the medial meniscus, where the ligament is broadest.

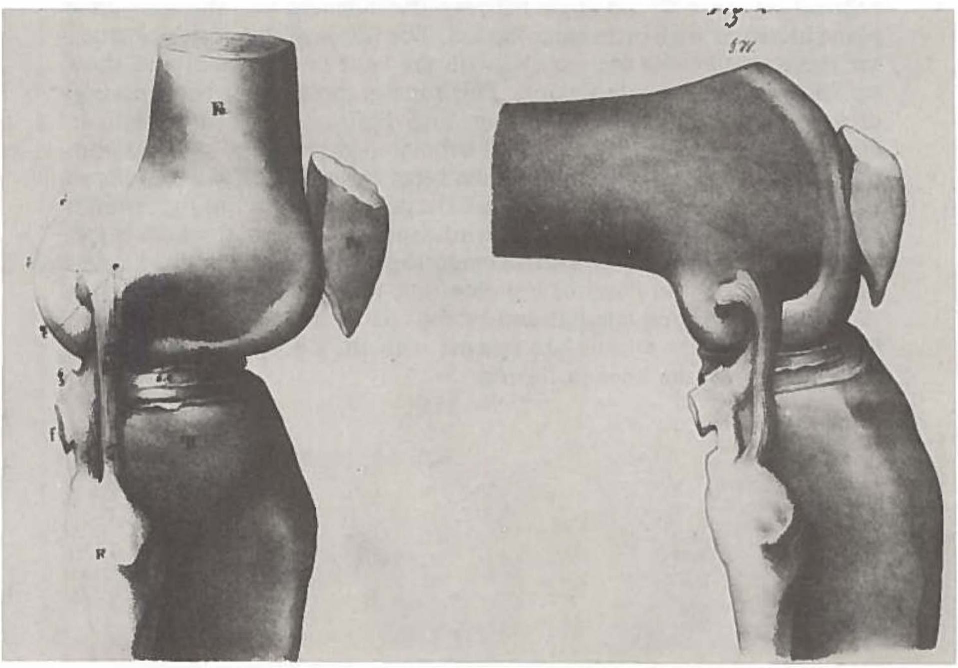
II.3.4. Fibular collateral ligament (lig. collaterale fibulare)

This ligament is circular in cross-section; its length is 5-6 cm and its diameter is 5 mm. Clearly separated from the joint capsule, it extends from the lateral epicondyle of the femur to the lateral and anterior part of the head of the fibula. The tendon of the popliteal muscle is located behind this ligament separated by a bursa.



Photograph 1: **tibial collateral ligament.**

Photograph 2: **fibular collateral ligament.**

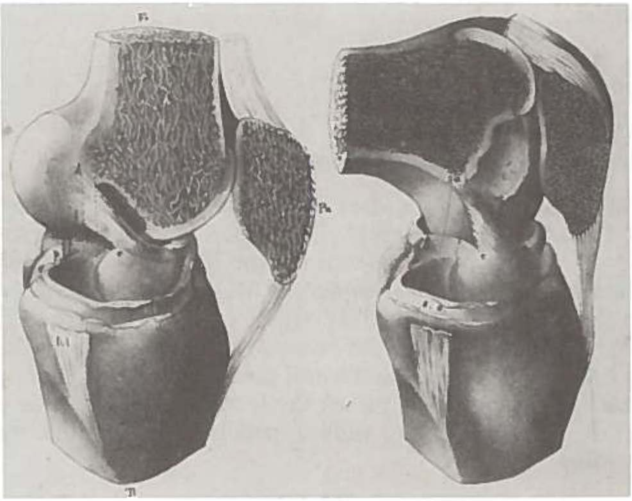


II.3.5. The anterior cruciate ligament (lig. cruciatum anterius)

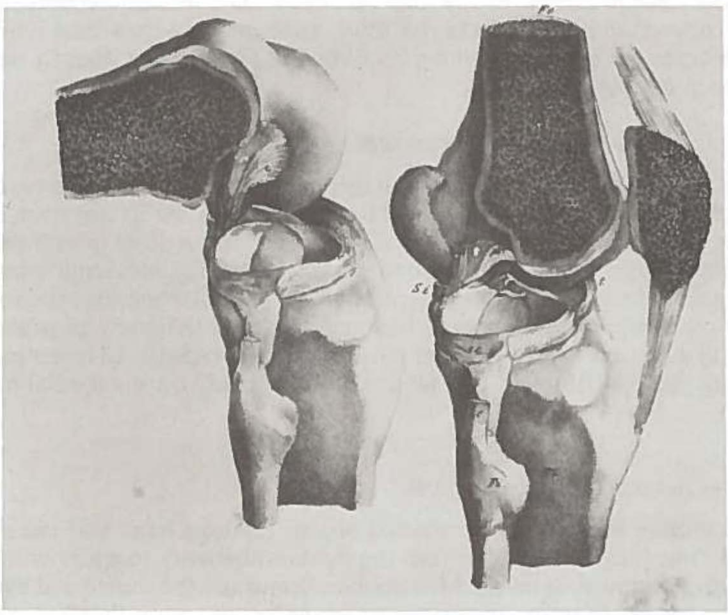
This ligament is oval-shaped in cross-section; it is about 4 cm long and its maximum diameter averages 11 mm. Proximally, it inserts on the posterior part of the medial facet of the lateral femoral condyle; distally, it inserts on the anterior tibial intercondylar area, immediately anterior and lateral to the medial intercondylar tubercle. Its course is thus oblique, from the posteroproximal to the anterodistal aspect. With the knee in extension the fibres are parallel; with the knee in 90° flexion they show torsion, which diminishes at endorotation of the tibia in relation to the femur, and increases at exorotation (photograph 3). The shortest fibres, which can be dissected out as a separate bundle, extend on the medial side.

II.3.6. Posterior cruciate ligament (lig. cruciatum posterius)

This ligament is narrower in its mid-portion than at its insertions. Its length is about 4 cm and its maximum diameter averages 13 mm, measured halfway its length. Proximally it inserts on the anterior part of the lateral facet of the medial femoral condyle, and distally on the posterior tibial intercondylar area, and partly on the posterior surface of the tibia. In this way the ligament extends from the anteroproximal to the posterodistal aspect, and the angle between the ligament and the transverse plane increases with increasing flexion. The fibres of the posterior cruciate ligament likewise are parallel with the knee in extension, and show torsion with the knee in flexion. This torsion increases at endorotation of the tibia in relation to the femur, and diminishes at exorotation. In view of the course of its fibres and behaviour during flexion-extension, the posterior cruciate ligament would seem to consist of two bundles: a smaller posterior bundle arising from the posterior aspect of the femoral condyle and inserting on the posterior aspect of the tibia, which is evidently contracted with the knee in extension and relaxed with the knee in flexion, and a larger anterior bundle which inserts more on the anterior aspect of the femoral condyle and extends to the intercondylar area; the fibres of the latter bundle are relaxed with the knee in extension and contracted with the knee in flexion.



Photograph 3: **anterior cruciate ligament.**



Photograph 4: **posterior cruciate ligament.**

Drawings by the Weber brothers (1836).

II.4. Muscles

II.4.1. Musculus quadriceps femoris

This muscular complex comprises the M. vasti mediali, intermedius, lateralis and the M. rectus femoris. The Mm. vasti arise from the femur, and the M. rectus femoris arises from the inferior anterior iliac spine and the lateral part of the iliac bone. the M. quadriceps inserts either directly on the mediolateral anterior aspect of the tibia, via longitudinal tendon fibres which extent in the extensor retinaculum, or indirectly on the tibial tuberosity via the patella and patellar ligament. These muscles are ensheathed in connective tissue: the fascia lata which ends on the tibia. Laterally this is very firm, and this part is called iliotibial tract (tractus iliotibialis).

II.4.2. Musculus popliteus

This muscle originates from the lateral femoral epicondyle and the knee capsule, close to the posterior horn of the lateral meniscus, and inserts on the tibia proximal to the linea M. Soleï. The tendon extends inside the capsule and is visible in the joint, covered only by a thin synovial membrane. A number of superficial muscle fibres insert directly on the arcuate popliteal ligament.

II.4.3. Musculus semimembranosus

This is a voluminous muscle which originates from the ischial tuberosity and inserts in the posteromedial region of the tibia. At its insertion it divides into three components: the direct (principal) tendon inserts on the medial tibial condyle and the popliteal fascia; the indirect tendon inserts more anteriorly on the tibia, parallel to the articular margin; the recurrent tendon (oblique popliteal ligament) extends obliquely in proximal lateral direction in the posterior part of the knee capsule, to insert on the femur. Several fibres of this tendon insert directly on the medial meniscus.

II.4.4. Musculus biceps femoris

This muscle has a double proximal origin: the long head and the short head. The long head arises from the ischial tuberosity together with the M. semitendinosus and the M. semimembranosus; the short head inserts on the femur. Distally, the two muscles merge into a joint tendon which passes around the lateral collateral ligament and inserts laterally and proximally on the head of the fibula.

II.4.5. Pes anserinus muscles: M. satorius, M. gracilis and M. semitendinosus

The M. sartorius is a long muscle originating from the superior anterior iliac spine. It extends lateromedially on the anterior side of the M. rectus femoris and M. vastus medialis and fans out to its insertion medial to the tibial tuberosity. The M. gracilis is a long, slender muscle which originates from the public bone and extends distally behind the M. sartorius to insert on the tibia distal to the insertion of this muscle.
The M. semitendinosus is a long structure with a muscular proximal and a tendinous distal half. It originates from the ischial tuberosity and extends behind the M. semimembranosus to the tibia, where it fans out to insert distal to the insertion of the M. gracilis, thus constituting the deepest layer of the pes anserinus.

II.4.6. M. tensor fasciae lata and iliotibial tract (tractus iliotibialis)

The M. tensor fascia lata is a long, flat muscle which originates from the iliac crest, ilium and superior anterior iliac spine. Its proximal one-third is largely muscular, while its distal two-thirds are tendinous. This tendinous part is the iliotibial tract, visible as a reinforcement of the fascia lata. This band extends from the iliac crest to the tibia near Gerdy's tubercle. A few fibres insert laterally on the patella.

II.4.7. Musculus gluteus maximus

This voluminous muscle, 4-5 cm thick, can be divided into a deep, a central and a superficial part. The superficial part plays a role in stabilization of the knee-joint by virtue of its insertion on the fascia lata. This part originates from the posterior part of the iliac crest, the posterior superior iliac spine, the posterior sacro-iliac ligaments and the sacrum.

II.4.8. Musculus gastrocnemius

This muscle originates laterally and medially from the femoral condyles via two flat, strong tendons, and directly from the posterior part of the knee capsule. It inserts on the calcaneal bone via the achilles tendon.

II.4.9. Musculus plantaris

This is a small, flat muscle which originates from a point just above and medial to the lateral femoral condyle, and extends between the soleus muscle and the gastrocnemius muscle. It inserts on the posterior aspect of the calcaneal bone just medial to the achilles tendon, and sometimes merges with the latter. Its role in the stabilization of the knee-joint is negligible.

II.4.10. Musculus articularis genu

This is a short, flat muscle originating from the ventrodistal part of the femur and inserting on the suprapatellar bursa. Its function is to stretch this bursa during extension of the knee.

II.5. Some functional aspects of the knee-joint

The human knee-joint combines a high degree of movability with good stability in all positions. Obviously the shape of the knee, the menisci, the knee capsule, the ligaments and the muscles surrounding the knee jointly play a role in this respect. The flexion-extension movement of this joint takes place largely above the menisci, whereas rotatory movement occurs largely below them. In the final part of the extension movement there is forcible exorotation of the tibia in relation to the femur, and most of the ligamentous and capsular structures are tightened. Meyer (1873) described this movement as „Schluszrotation'' (final rotation). Not only the site of insertion of the ligaments but also the elasticity of the fibres and their shortening by elasticity and torsion play a significant role. The degree of elasticity of the cruciate ligaments and the medial collateral ligament has been studied in detail by Girgis, Wang, Warren and others.

Extension involves tightening of the following ligamentous structures: posterior knee capsule, dorsal part of the posterior cruciate ligament, most of the anterior cruciate ligament, posterior part of the medial collateral ligament and the lateral collateral ligament.

The **first 10° flexion** of the knee involves further tightening of the smaller anteromedial part of the anterior cruciate ligament, and a posteroanterior shift of the tension in the medial collateral ligament.

Further flexion involves relaxation of the posterolateral part of the anterior cruciate ligament, the posterior part of the posterior cruciate ligament, the posterior knee capsule, the posterior part of the medial collateral ligament and the lateral collateral ligament, and tightening of the anterior two-thirds of the posterior cruciate ligament and the anterior part of the medial collateral ligament.

At maximum exorotation of the tibia in relation to the femur, the fibres of the anterior cruciate ligament and the long tibiofemoral fibres of the medial collateral ligament are tout, both in extension and in flexion.

At endorotation the posterior cruciate ligament tightens, and the anterior cruciate ligament relaxes (the torsion of the ligament also plays a role in this respect).

CHAPTER III

MECHANICS OF THE KNEE-JOINT

III.1. Kinematics

III.1.1. Introduction

With reference to a number of basic principles, this chapter discusses the movements of the knee-joint in space, as projected in three planes which are perpendicular to each other: the sagittal, the frontal and the transverse plane. Mention is made of the results of personal observations on these movements in the frontal and the transverse plane.

III.1.2. Some aspects of kinematics

The movements of one or several points in space can be analysed by projecting these points in three planes which are perpendicular to each other. The movement of a segment AB in relation to an immobile segment A'B' in a given plane can be: rotatory, translational or a combination of these two. A rotatory movement involves a fixed rotation axis; in a translational movement there is no rotation axis; a combination of a rotatory and a translational movement involves a moving rotation axis, which Fick (1911) described as an evolute.

III.1.3. The flexion-extension movement

The Weber brothers (1836) compared the movement of the femoral condyles in relation to the tibial plateau with the movement of a wheel which slides as well as rolls in relation to the supporting layer. These movements were subsequently studied by Zuppinger)1904) by means of radiological projection from the lateral aspect, and by Fischer (1907), who projected the knee from the medial aspect. Using the Fischer technique, Fick calculated the rotation centres. He drew perpendiculars to the tangent at the sites of contact between tibia and femur in consecutive frames. The intersection of each perpendicular with the next determined the rotation centre. In this way Fick obtained a series of points which, together, made up what he called an evolute (cf diagram 2). He obtained the evolute of the femoral condyles by studying a femur moving in relation to a fixed tibia, and that of the tibial condyles by studying a tibia moving in relation to a fixed femur. However, since the medial and lateral femoral condyles and tibial plateaus differ in shape and spatial position, it can be stated that there are four sagittal evolutes for the tibiofemoral joint.

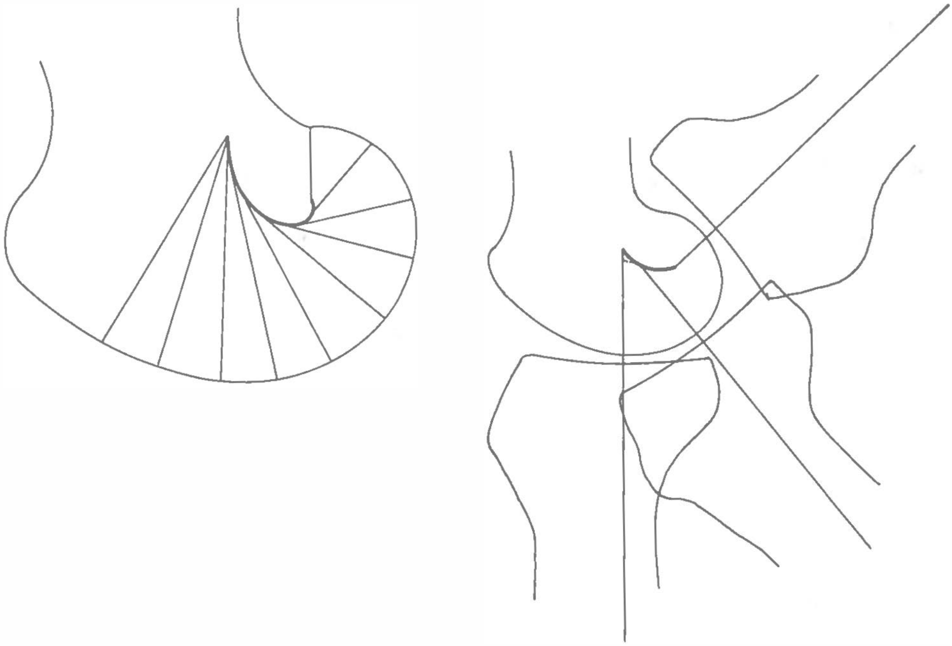


Diagram 2 Ch. III: evolute of the medial femur- and tibiacondyle (Fick).

Movements in the frontal and in the transverse plane take place simultaneously with a movement in the sagittal plane. Bousquet (1977) maintained that a tibia moving from maximum extension to flexion also executes an endorotatory movement, slides back and deviates in varus position. The knee executes the reverse movement when moving from flexion to maximum extension. The movement in the frontal plane is due to the asymmetrical shape of the two condyles and the tibial plateau. For a detailed study of the movement in the frontal plane, anteroposterior roentgenograms were made of two normally stressed knees. We compared the projections in maximum extension, 20° flexion, 40° flexion and 80° flexion. Superposition of consecutive roentgenograms revealed a rotatory movement of the tibia in relation to the femur, with the rotation axis at the level of the projected intercondylar process of the tibia. The quantitative determination was made by measuring the change of angle between tibia and femur at different flexions of the knee-joint (cf diagram 3 and table 1). The total variance between 0° and 80° flexion was 3.5° for the right and 5° for the left knee.

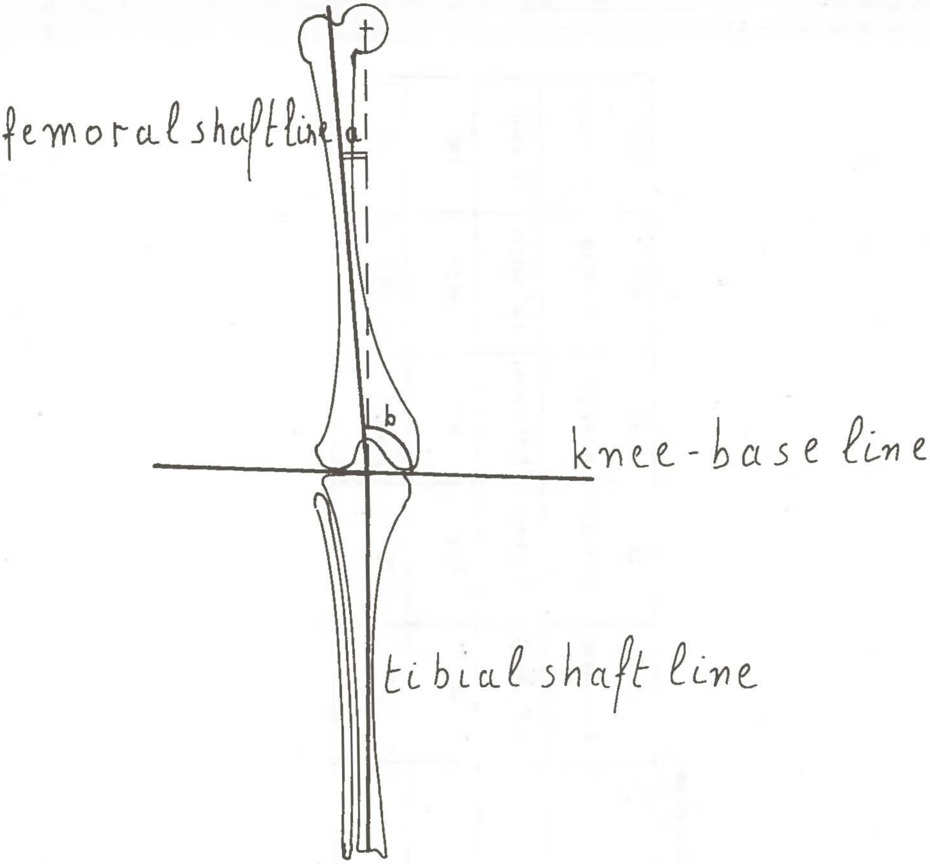


Diagram 3 Ch. III: **the tibio-femoral shaft angle and the knee-base femoral shaft angle projected in the frontal plane.**

The angle between knee-base line and femoral shaft showed a variance of 3.5° for the right and 2.5° for the left knee.
The involuntary rotatory movement (conjunct rotation) is expressed mainly during the first 15-20° flexion or the last 15-20° extension of the knee. This movement is due to the structure of the knee-joint, and the cruciate ligaments play an important role in it (Husson 1973; Menschik 1975). This movement was studied by Braune and Fischer (1891), who observed a total change of angle of 5° and 6°. Helfet (1974) wrote that, in a stressed knee-joint, this rotatory movement is not confined to the last degrees of extension or the first degrees of flexion, but is observed throughout the flexion-extension movement. He maintained that a flexion-extension movement without corkscrew movement can lead to a meniscal or a cruciate ligament lesion.

Table 1 - chapter III: knee flexion projected in the frontal plane.

degrees of flexion	0°	20°	40°	60°	80°
tibio-femoral shaft angle (angle a) right knee	2,5° valgus	3,5° valgus	4° valgus	7° valgus	3° valgus
tibio-femoral shaft angle (angle a) left knee	2,5° valgus	1° varus	1,5° varus	3,5° valgus	1° varus
tibial plateau-femoral shaft angle (angle b) right knee	96°	97,5°	97°	99,5°	99°
tibial plateau-femoral shaft angle (angle b) left knee	97°	97°	96,5°	97°	95°

III.1.4. The voluntary rotatory movement (adjunct rotation)

This movement is only possible after 20° flexion and has its maximum excursion at about 90° flexion; it diminishes upon further flexion but is still possible to some extent at maximum flexion. Morcher (1975) measured the voluntary exorotatory and endorotatory movements of 42 knees in a physiological situation. At 90° flexion, exorotation averaged 21.4°, while endorotation averaged 15.0°. This movement is described in the literature as rotatory with a fixed axis. There was some discussion between various authors about the question whether this rotation axis extended through the centre of the tibial plateau, or slightly medial to it. It was assumed that this rotation axis shifted upon a change of the angle of flexion, the consecutive shifts producing a spiralling curve in the plane of the tibial plateau. For further study of this movements, two studies of anatomical specimens were made.

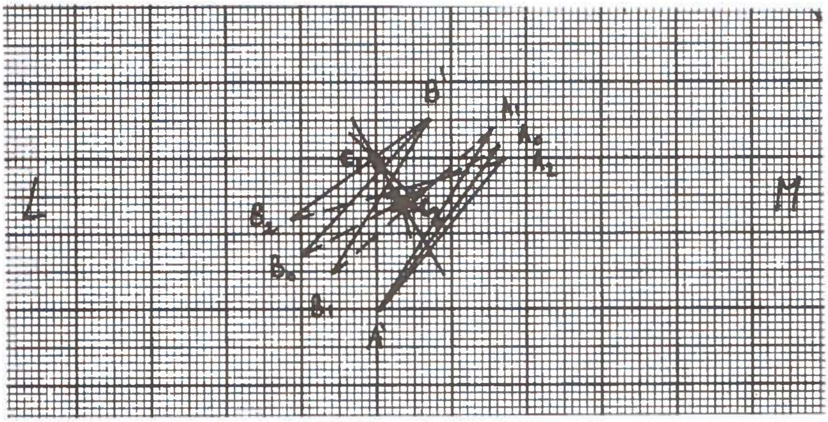
The first was a radiological study of a knee specimen in which all insertions of the cruciate ligaments had been marked with the aid of lead pellets. The knee-joint had been so dissected that only the ligaments and the menisci remained intact, the tibia having been fixed on a plastic plate. The knee-joint was placed in 45° and 90° flexion; it was placed in maximum endorotation, in the neutral position and in maximum exorotation. Roentgenograms were obtained with the beam perpendicular to the tibial plateau, thus achieving a projection of the immobile tibial insertions and the moving femoral insertions. The centres of the projected lead pellets were marked on graph paper. The projections of the femoral points of insertion were designated A0 B0, A1 B1 and A2 B2 (cf diagrams 4 and 5). The mid-perpendiculars of these segments intersect in two different points, C1 and C2. There is no question of a fixed rotation centre either with the knee in 45° flexion or with the knee in 90° flexion.

For the second study, 11 formalin-preserved knees were dissected down to the extensor retinaculum. the femur was fixed and the tibia was left mobile in all directions (passive movement with the aid of the foot). About 1 cm beneath the tibial plateau a long and a short bar were screwed into the tibia perpendicular to each other. A small hole was drilled through each end of the long bar and through one end of the short bar, in such a way that three sharp styli could be inserted in these holes (cf photograph 5).

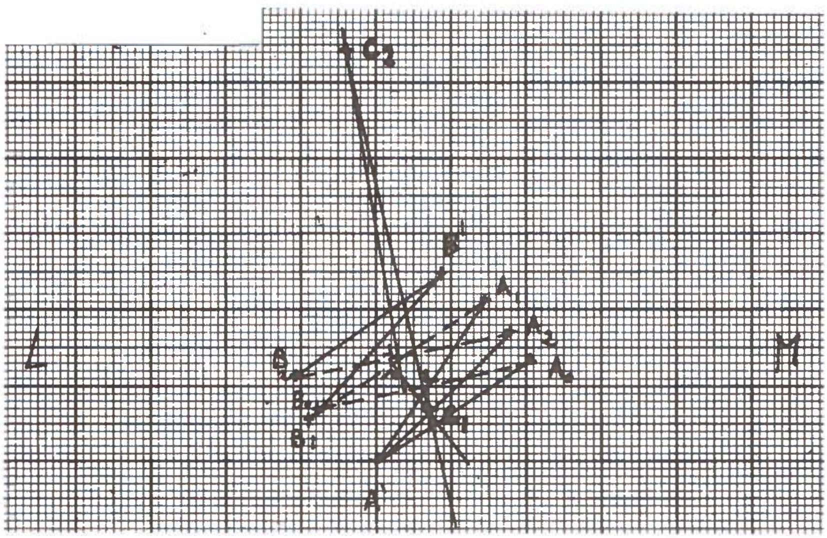
The rotatory movement of the knee at three points was marked stepwise on graph paper. After the study, the dissected proximal part of the tibia, with the bars in situ, was submitted to roentgenography with the beam perpendicular to the tibial plateau. the mid-point of the longest stylus was taken as point of reference for determination of the centre of the tibial plateau in the schematic situation (designated C in diagrams 6 through 8). The rotation centres were determined by the already described principle, making use of the intersections of the mid-

Diagrams 4 and 5 Ch. III: rotation centres of the knee in 45° and 90° flexion.

45°



90°



A'B' = tibia
A. B. = femur in neutral position
A, B, . femur in max. endorotation
A_2 B_2 - femur in max exorotation
C_1 = endorotation centre
C_2 = exorotion centre

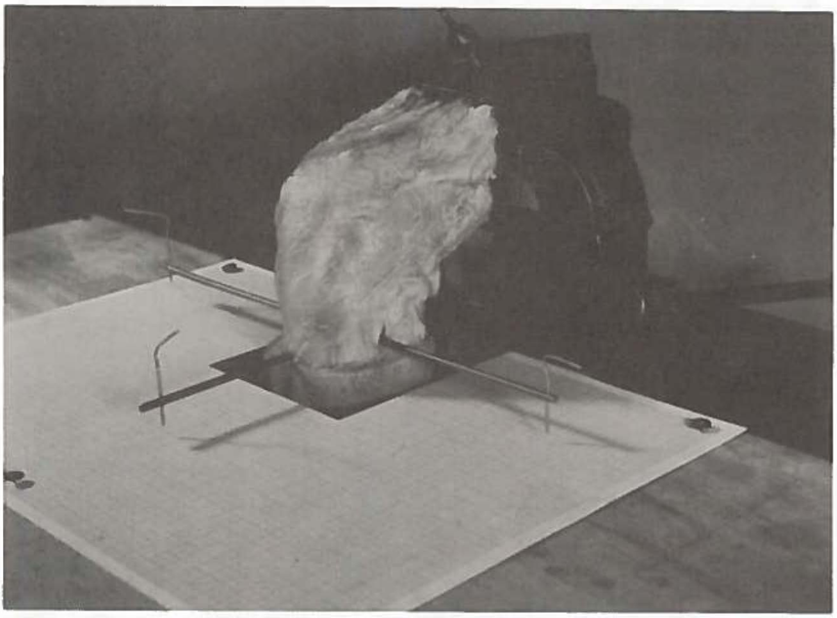
perpendiculars. A simple mathematical calculation was used in this study.

Limitations of the study

Due to the limited excursion of the knee-joint movement in the transverse plane at exorotation and endorotation, analysis is possible only after magnification. In that case, however, any inaccuracy of determination is similarly magnified. The results obtained in an anatomical specimen need not be identical to those obtained in a knee-joint functioning in vivo.

Results of the study (cf diagrams 6 through 8)

The results obtained in this study can be described as follows. In none of the knees was a fixed rotation point found; an evolute was found in all. This evolute showed an unmistakable variability in position and shape in the different knees, but also in the same knee if flexion or the varus-valgus position was changed, or if capsule or ligaments were severed. A few constants can be mentioned:
Most evolutes were found in the medial or central part of the tibial plateau at 90° flexion. At 30° and 60° flexion, the evolute shifted anterior-

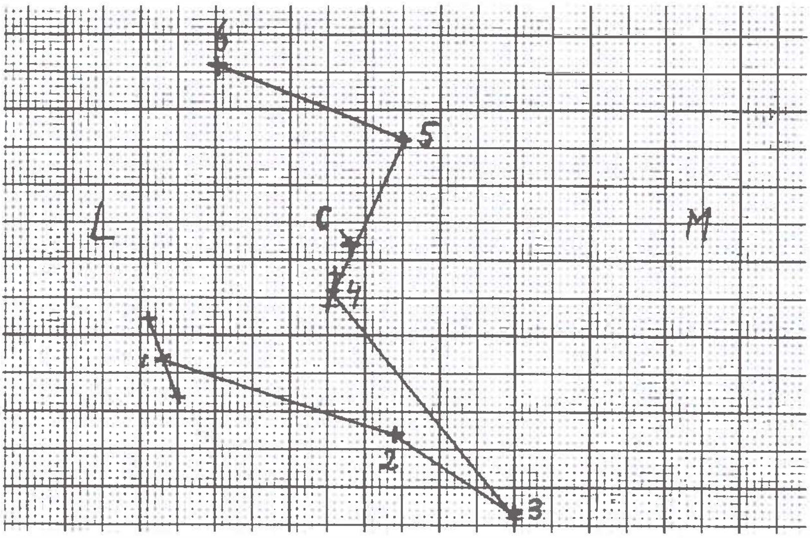


Photograph 5: knee specimen in place for the determination of the rotation centres.

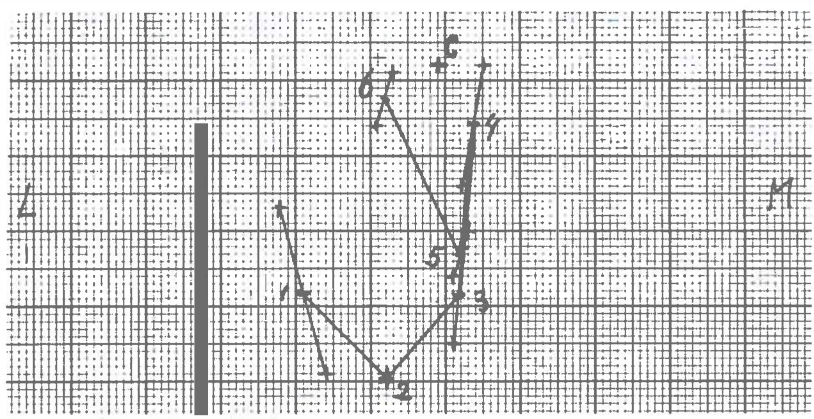
ly. The evolute showed lateral or posterior displacement when the medial capsule or ligamentous structures were cut. The endorotatory segment of the curve showed medioposterior displacement when the lateral knee capsule was severed.

Diagram 6 CH. III: rotation centres of knee in 30 °, 60° and 90° flexion.

30°



60°



90°

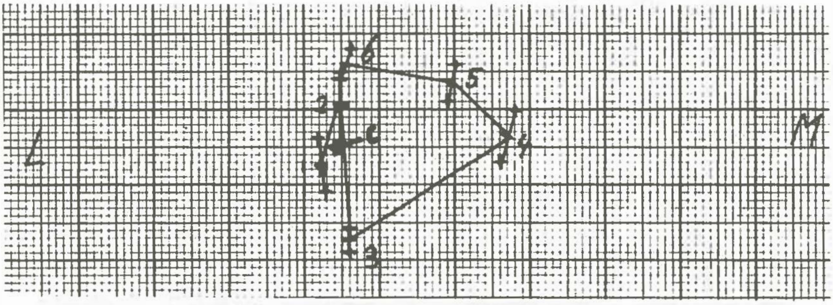
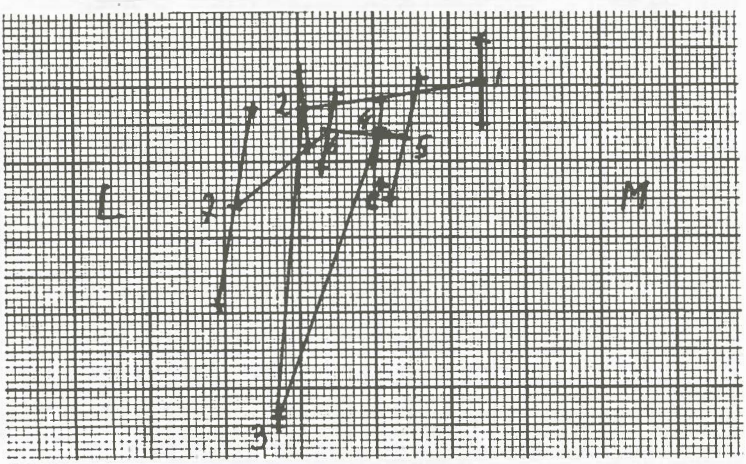


Diagram 7 Ch. III: rotation centres of knee in 90° flexion, after cutting the medial ligamentous structures (a) and the anterior cruciate ligament (b).

(a)



(b)

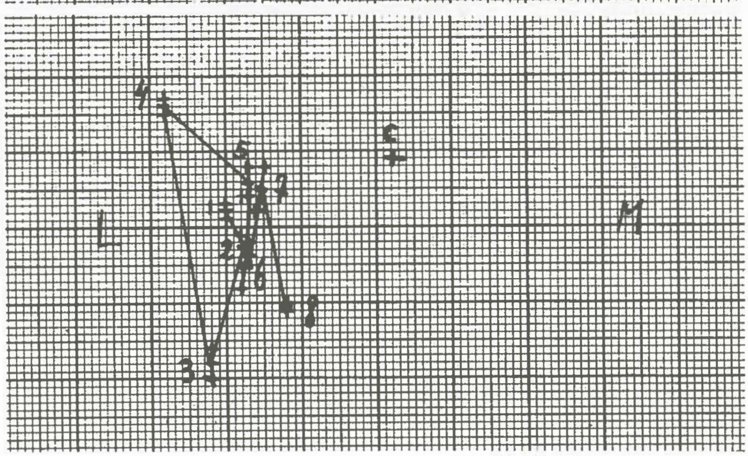
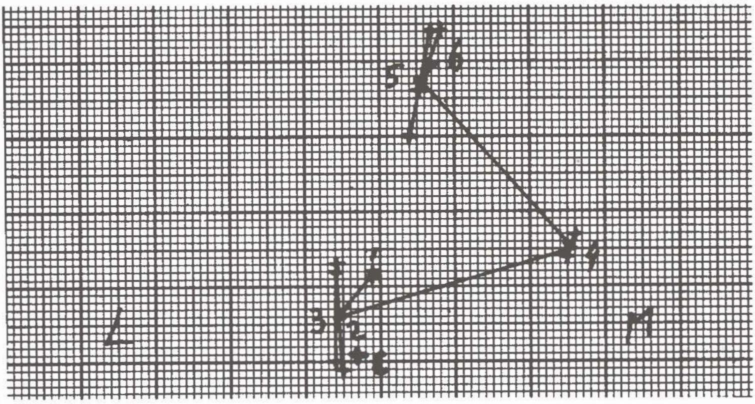
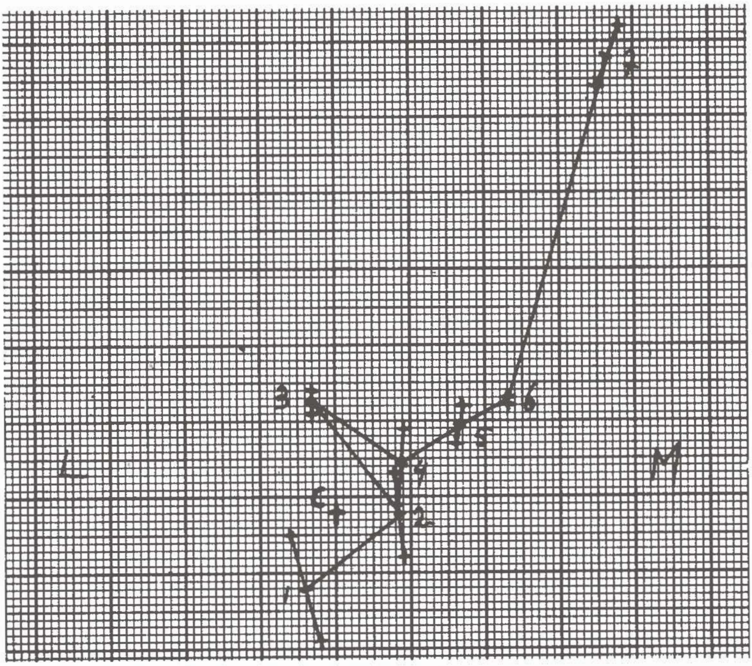


Diagram 8 Ch III: rotation centres of knee in 90° flexion (a), and after cutting the lateral ligamentous structures (b).

(a)



(b)



1 = centre of max. exorotation
6, 7, 8 = centres of max endorotation
3, 4 = centres of neutral position
c = centre of the tibial plateau

III.2. Dynamics

III.2.1. Introduction

The interaction of forces in a knee-joint during walking is very complicated. The shape of the knee-joint, its cartilage, ligaments capsule and muscles, have developed into a single functional unit which ultimately is a compromise between maximum stability and maximum mobility. We do know that bone and cartilage can best withstand compression forces, whereas ligaments, capsule and muscles mostly cope with traction forces. In view of the localization and structure of the joint and the great leverages, we assume that great forces act on the joint. A direct study of these forces in vivo is as yet impossible. There are two possibilities of investigation in what can be described as a schematization of the real situation:

1) direct study of forces in an anatomical specimen;
2) indirect study of forces on the basis of the change in centres of gravity involved in a known movement.

The majority of authors who prefer the latter approach, accept the dynamic model introduced by Braune and Fischer (1889).

In biomechanics, vectors are used for calculation of forces. A vector is the representation of a force of known magnitude, line of application, sense and point of application. The resultant of two or several vectors can be drawn and calculated with the aid of a vector diagram. To simplify calculation, one first determines the forces as projected in a single plane; the force exerted in space can then be calculated on the basis of two planes which are perpendicular to each other. For this calculation, a brief situation of transient equilibrium is usually chosen. This situation exists when the sum of forces and moments of force equals zero. When a body is not in equilibrium, acceleration occurs.

III.2.2. Dynamics of the knee-joint as projected in the frontal plane

In principle, each of the two knees of an individual standing on both legs bears an equal part of the individual's body weight. This is a stable situation, and the muscular strength required to maintain the body's equilibrium is small. When the individual stands on one leg, gravity exerts an adductive moment of force on the knee-joint. In order to ensure a balance of forces and moments of force, a force on the lateral side is required: in this case traction on the iliotibial tract, the fibular collateral ligament and the femoral biceps muscle (traction force L). The situation is schematically shown in diagram 9. The magnitude and sense of this adductive force P can be determined on the basis of studies by Braune and Fischer. In the one-legged stance, P is 93% of the body weight. L can be calculated with the aid of the equation $P \times a = L \times b$. the point of application, sense and magnitude of the resultant R can be calculated by comparing the trabecular structure of the tibial plateau with the pattern

of forces of a photo-elastic model. Maquet (1976) found that the dynamic centre was also the centre of the projected tibial plateau.
He calculated R with the aid of the equation

$$R = \quad P^2 + L^2 + 2\ PL \cos (PL).$$

He calculated the sense with the aid of the equation

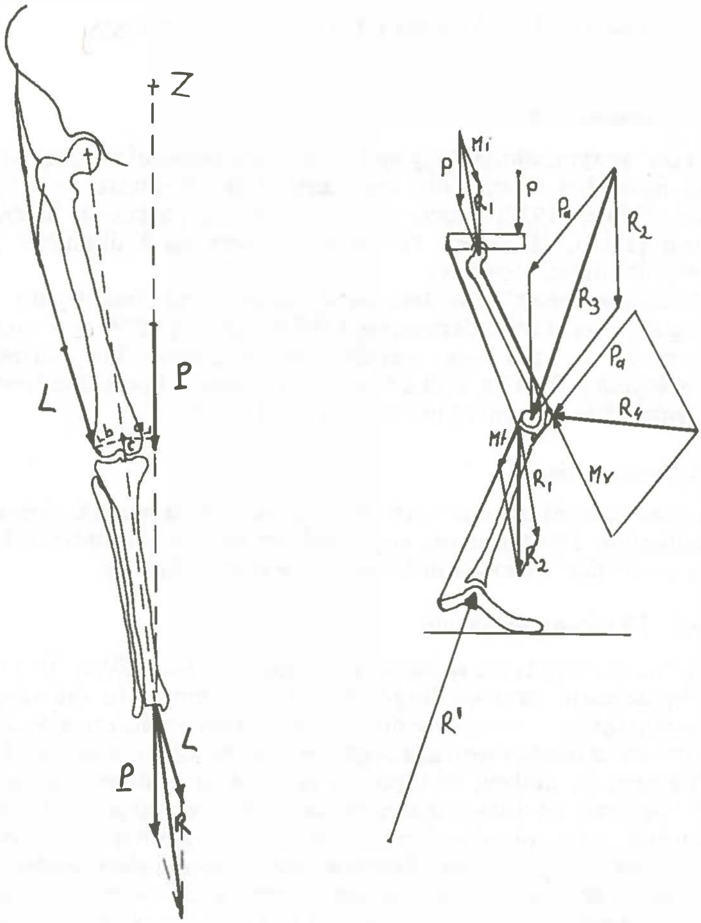
$$(PR) = \frac{L}{R} \sin (PL).$$

His calculations, based on Braune and Fischer's test subject I (58.7 kg), showed that in the one-legged stance R = 126.824 kgf and PR = 5°.

III.2.3. The dynamics of the knee-joint as projected in the sagittal plane

The effect of the muscles and the displacement of the body's centre of gravity in relation to the knee-joint are of importance for the analysis of forces which take effect during walking. To calculate the effect of the muscles, we primarily work with the knee-joint in slight flexion and the ankle-joint in slight plantarflexion. As indicated in diagram 10, we see that in this position the partial body weight P is localized on the anterior aspect of the femoral head. The gluteus maximus and the adductor magnus muscles keep the pelvis balanced and also produce a force of flexion in the knee (both indicated as Mi). The gastocnemius muscle produces a flexion-inducing force Mt. R2 is the ultimate resultant of these three forces.
To counteract this force of flexion, the femoral quadriceps muscle develops force Pa via the patellar ligament. R3 is the ultimate resultant of these two forces: it is a compressive force, exerted in the tibiofemoral joint. The quadriceps muscle which exerts force Pa on the tibia, does so via the patella by a force Mv, with as resultant R4, which causes compression in the patellofemoral joint. The parallel displacement of vectors Pa and R2, as indicated in diagram 14, induces two moments of force of equal magnitude and line of application, but reversed in sense. With the body in a situation of equilibrium, R3 and R4 are counteracted by two reactive forces (R'3 and R'4) of equal magnitude, point of application and line of application, but reversed in sense. The moments of force and the vectors R'3 and R'4 are not indicated in the diagram. Maquet (1976) calculated the forces exerted on the knee in two planes, starting from the calculations made by Braune and Fischer in a test subject weighing 58.7 kg. He calculated the effect of body weight R and that of muscles F on the knee-joint during the unipedal walking phase (phases 12 through 23 according to Braune and Fischer). R varied from 28.61 kg to 60.46 kg and F varied from 25.69 kg to 292.54 kg. The ultimate resultant gave a curve with two peaks: one in the heel stance (stance 12 - 353 kg) and one in the toe stance (stance 23 - 297.66 kg), separated by a dip (stance 17 - 54.3 kg).

Diagrams 9 and 10 Ch. III: **forces exerting on the knee joint, when the individual stands on one leg, as projected in the frontal and sagittal plane.**



z = centre of gravity standing on one leg
p = partial body weight
L = traction force on the iliotibial tract
a, b = shortest distance between P, L and c
M_i = force induced by M. gluteus max, M. adductor magnus
M_t = force induced by M. gastrocnemius
M_v = force induced by M. quadriceps femoris
P_a = force in patellar ligament
R, R_1, R_2, R_3, R_4 = resultant of forces
diagrams following Maquet

CHAPTER IV

SYMPTOMATOLOGY AND CLINICAL DIAGNOSIS

IV.1. Introduction

Data on the symptomatology and clinical diagnosis of chronic posttraumatic instability of the knee are scanty in the literature. In his monograph, Palmer (1938) presented a survey of this diagnosis. Slocum and Larson (1968), Hughston (1976) and others have discussed certain aspects of clinical diagnosis.
This chapter presents the data on 60 patients examined by the author during the period from September 1975 to January 1978, in whom instability of one or both knees was clinically diagnosed. The patients were 51 males and 9 females with a total of 64 unstable knees; they ranged in age from 15 to 67 years (average age 28.3 years).

IV.2. Anamnesis

The anamnesis of ligament instability is part of the general orthopaedic examination. The traumatic event and the specific symptomatology receive particular attention in taking the patient's history.

IV.2.1. The traumatic event

A traumatic event is the cause of most ligament instabilities. In a few cases the accident may be forgotten, as subordinate to the secondary symptomatology. It is rarely possible to obtain an accurate account of the traumatic mechanism, although the type of injury is usually known. Of the patients studied, 26 reported an incident of direct violence, and in 20 there was an unmistakable rotatory stress component. Pure hyperextension was involved in 2 cases, and a combination of hyperextension and rotation existed in one. The remaining patients were unable to give an accurate account of the traumatic event. In 24 cases the injury had been sustained in a sports setting, and in 35 cases a traffic accident was involved. The interval between traumatic event and examination was less than 1 week in 2 cases; in the remaining 58 cases is ranged from 6 months to 29 years (average interval 4.2 years).

IV.2.2. Symptomatology

There are no symptoms which are pathognomonic of ligament instability of the knee. The most common symptoms observed in these cases are pain, fatigue after a walk, difficulty in negotiating rough terrain, difficulty in walking stairs, an uncertain feeling, dragging of a leg, sagging through the knee, hitching and swelling. The sense of fatigue, difficulty

in negotiating rough terrain and walking stairs can be interpreted as indicating controlled instability. Sagging indicates instability which is no longer under control. Pain, too, can indicate controlled instability; but pain which accompanies sagging indicates instability which is no longer under control.
Of our 58 patients with chronic instability of the knee, 47 reported pain, 39 an uncertain feeling or fatigue, 44 sagging, 8 hitching, and 35 a recurrent swelling.
A separate clinical picture is the clicking knee, described by Palmer as early as 1938: the patient feels that dislocation of the knee occurs, and suddenly sags through it. The knee then becomes swollen. The cause is subluxation of the knee-joint, causing the femoral condyle to slip past the edge of the meniscus. Palmer described an anterolateral subluxation. Slocum and Larson (1968) later described an anteromedial subluxation.
A second separate clinical picture is that of more or less painful restriction of extension. This is related to a previously sustained collateral ligament lesion. Palmer observed this symptom in 5% of his patients with clinically unmistakable collateral ligament lesions. Smillie (1973) described it in relation to a Pellegrini-Stieda shadow. In our series, we observed this symptom in one patient.

IV.2.3. Previous diagnosis and therapy

Acute ligament lesions are as a rule diagnosed more readily than chronic instability of the knee ligaments. This is because the symptomatology of the latter is not specific; the instability is sometimes a component of a multiple injury of the limb, often associated with a meniscal rupture and chondropathy (cf Chapter VI). It is not surprising that most of these patients prove to have a history of a previous operation. Of the patients we studied, 4 had been treated by ligament suture, 17 with plaster of Paris for primary ligament instability, 6 exclusively for a fracture (conservative or operative treatment). A meniscectomy had been performed on 16 knees, including 5 in which both the medial and the lateral meniscus had been removed. In 4 cases there had been various other therapies.

IV.3. The examination

The examination of ligament instability, too, is part of a general orthopaedic examination. We intend to discuss the knee examination carried out with the patient walking and standing, and the knee examination made on the examining table.

IV.3.1. Knee examination during weight bearing

Important features are deviations of the leg axis, walking and hopping. In walking, the standing phase is usually abbreviated; hopping is often

difficult or impossible. In some cases the kneejoint is fixed; in other cases the lateral stability is visible while walking. The drawer sign can sometimes be provoked by contracting the muscles. Palmer (1938) described this situation as active drawer sign. The anterior active drawer sign is provoked by placing stress on the slightly flexed knee. The tibia then slides forward and can be repositioned by contracting the muscles. The posterior active drawer sign is seen when the knee is flexed 90® in a sitting position. Upon contraction of the quadriceps and the hamstring muscles, the proximal part of the tibia is pulled back.
We observed an axis deviation in 2 of our patient, both of whome showed genu varum. A disturbed pattern of locomotion was observed in 36 patients; in 20 patients the pattern was undisturbed, while in 4 patients there was no record of the pattern of locomotion. Hopping was disturbed in 25 cases, undisturbed in 16, and not on record in 19 cases. In the patient whose vastus lateralis muscle and fascia lata had been excised, both locomotion and hopping were found disturbed. An anterior active drawer sign was observed in 2, and a posterior active drawer sign in 4 cases.

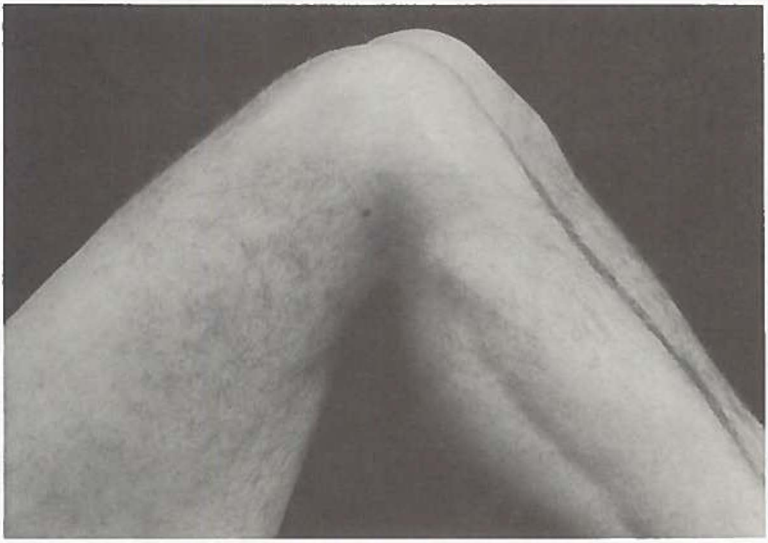
IV.3.2. Passive knee examination

a) Inspection
The inspection focuses on the position and shape of the knee, scars (if any), and the shape of the quadriceps muscle in relaxation and contraction. Atrophy and hypotonia of the quadriceps muscle (i.e. mostly of the M. vastus medialis) is often found. If there is hydrops, the possibility of associated pathology (e.g. ruptured meniscus or chondropathy) is to be taken into account. Of our patients, 29 showed unmistakable quadriceps atrophy, 12 showed hydrops, which further examination revealed to be related to a chondropathy in 6 and to a meniscal lesion in 3.

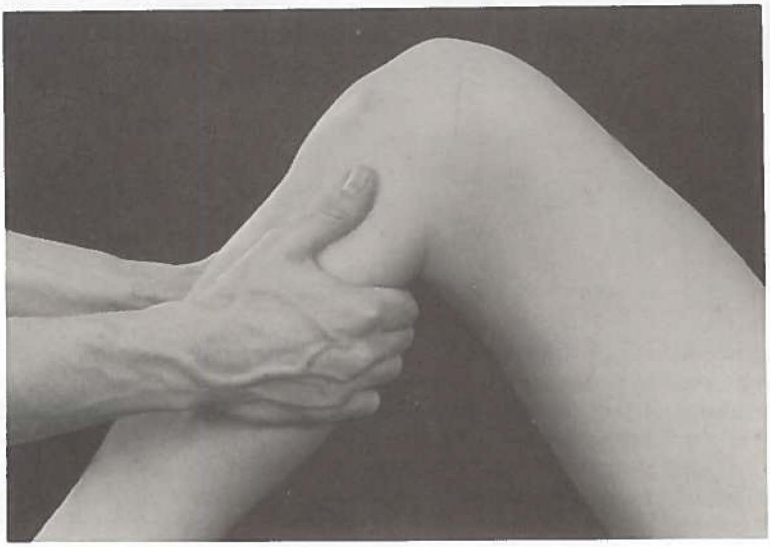
b) Active and passive knee movements
The patient is examined to establish whether hyperextension exists and, if so, whether this is symmetrical or asymmetrical. Function is likewise tested. The knee is palpated for possible fine crepitations. The conventional meniscus tests are performed.
We found symptoms of a meniscal rupture in 3, fine crepitation in 11 and distinct limitation of movement in 2 of our patients. Asymmetrical hyperextension was found in 12, and was associated with an anterior drawer sign in 8, with a posterior drawer sign in 1, and with both an anterior and a posterior drawer sign in 3 cases.

c) Passive stability testing
We tested lateral stability in maximum extension or hyperextension and in 30° flexion of the knee. In extension it is usually quite possible to differentiate between medial and lateral instability, but in flexion it is not. In principle, near-extension as indicated in the Netherlands Manual of

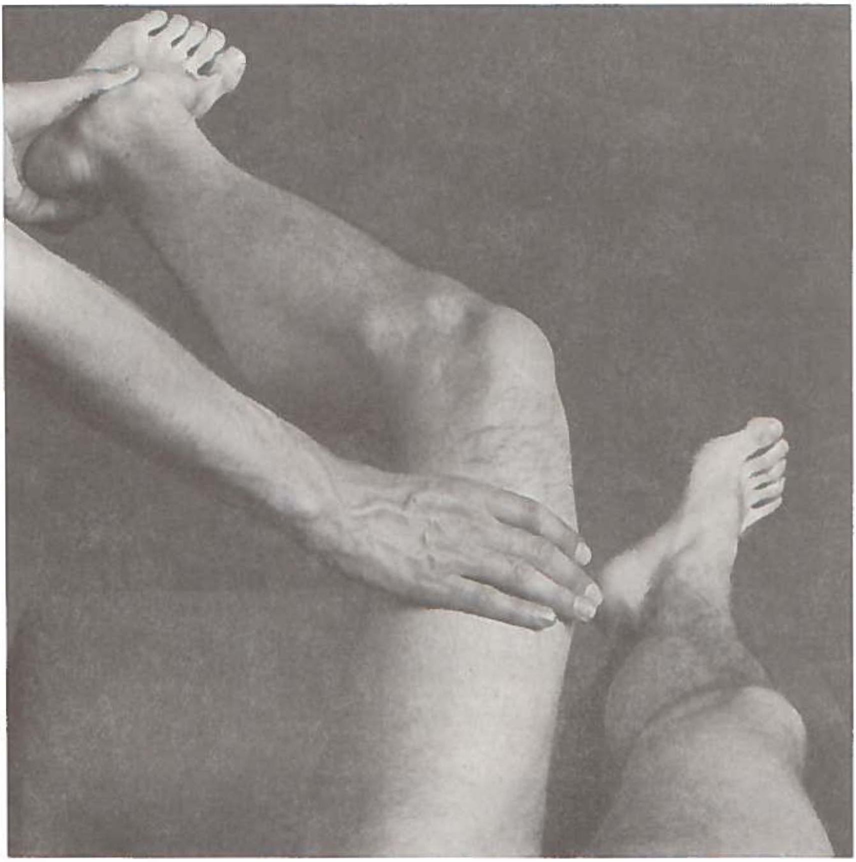
Orthopaedics can be chosen instead of 30° flexion. Comparison between the affected and the unaffected knee is important. Both knees are then placed in 90° flexion with the feet on the bench. If the tibia slides back spontaneously as apparent already at inspection (photograph 6),



Photograph 6: **posterior drawer sign.**



Photograph 7: anterior drawer sign.



Photograph 8: pivot shift test.

then we have a positive posterior drawer sign. In a few cases the tibia can be pushed further back. The investigator then sits down on the patients foot, places his hands in the popliteal fossa and gently pulls the knee forward (photograph 7). In the case of an anterior as well as in that of a posterior drawer sign, comparison between the affected and the unaffected knee is essential. The same test is then repeated with the foot in maximum endorotation and in 15° exorotation, as described by Slocum (1968). The last test is the pivot shift test, as described by McIntosh (1974): the lower leg is kept in endorotation, while slight valgus stress is exerted on the thigh. Passive flexion and extension movements of the knee are then executed, from 0° to 90° (photograph 8). A positive pivot shift is recorded when this movement is not smooth and continuous but characterized by a distinct jump. In the case of ligament instability the jump is caused by subluxation in the lateral tibiofemoral compartment. The patient often indicates that this movement is the exact imitation of his complaint.

d) Interpretation of clinical findings

For systematization of the written record of the results of the clinical examination, it is important to use an established code. This is why the instability had been named after the site of excessive mobility in relation to the dynamic axis of the knee (cf Chapter III). Projecting this mobility in the frontal and sagittal plane of the body, we can identify it as anterior, posterior, medial and lateral instability. The instability can be manifest in one sense (simple instability) or in several senses (compound instability). In principle, any combination of instability senses is possible.
Every instability involves an abnormal rotatory movement in the transverse plane (cf Chapter III). However, this abnormal rotation can be extreme when subluxation of the knee-joint occurs, producing the clinical picture of the clicking knee or, as Slocum (1968) called it, rotatory instability.
The clinical findings cannot always be translated directly into ligament instability; nor is it always possible to determine the initial position. It is therefore not always possible to differentiate between medial and lateral instability, or a combination of the two (cf Chapter VII).
There is a relation between an anterior drawer sign and an anterior cruciate ligament lesion, and between a posterior drawer sign and a posterior cruciate ligament and posterior capsule insufficiency. There is also a relation between medial instability of the knee in flexion and insufficiency of the medial knee capsule and possibly of the medial collateral ligament, and between lateral instability of the knee in flexion and insufficiency of the lateral knee capsule and possibly of the lateral collateral ligament. Lateral instability in extension or physiological hyperextension is an expression of severe instability with insufficiency of a collateral ligament, both cruciate ligaments and the posterior knee capsule or part of it.
The results of the passive stability tests in our patients are presented in table 2. A positive pivot shift test was observed in 8 cases, and was related to anterolateral instability in 6 (5 with an anterior cruciate ligament lesion and 1 with an intact anterior cruciate ligament). It was related to a lesion of the medial meniscus in 2 cases, and to joint laxity after excision of the M. vastus lateralis and the iliotibial tract in 1 case. A positive Slocum test with the anterior drawer sign more marked in exorotation than

in the indifferent position, was observed in 5 patients (always in association with an anterior cruciate ligament lesion).

Table 2 - chapter IV

Clinical diagnosis of 64 instable knees	
A. Simple instability:	
Medial instability	2
Lateral instability	3
Collateral instability	5
Anterior instability	2
Posterior instability	8
Total	20
B. Compound instability	
Antero-medial instability	4
Antero-lateral instability	3
Antero-medio-lateral instability	1
Antero-collateral instability	22
Postero-medial instability	1
Postero-lateral instability	2
Postero-collateral instability	2
Antero-posterior instability	3
Antero-postero-lateral instability	5
Total	43
C. No passive instability	1

CHAPTER V

RADIOLOGICAL EXAMINATION

V.1. Introduction

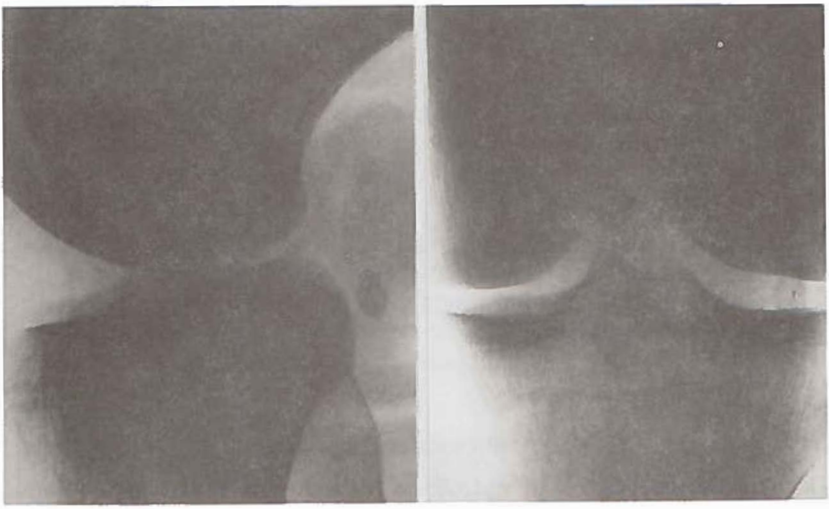
Radiological examination is essential in all cases of knee injury, and certainly also in the case of persistent complaints following a knee injury. This chapter discusses roentgenography without contrast medium, arthrography and roentgenography under stress, with reference to data from the literature and personal observations on instability of the knee ligaments.

V.2. Roentgenography without contrast medium

In the orthopaedic department of the University Hospital, Groningen, roentgenograms of both knees are routinely obtained in four projections: anteroposterior, lateral, tangential patellar projection and tunnel view.
The anteroposterior projection permits of adequate evaluation of the tibiofemoral joint. It reveals degenerative changes such as diminished articular space, osteophyte formation, sclerosis and irregular contours. The Pellegrini-Stieda shadow and avulsion fracture of the fibular head are likewise visible in this projection.
The lateral projection permits of evaluation of the patellofemoral joint. It also visualizes avulsion fracture of the anterior and posterior tibial intercondylar areas and osteophyte formation on the anterior aspect of the medial tibial intercondylar tubercle.
The tunnel view is used in the diagnosis of osteochondritis dissecans. It also most clearly visualizes exophyte formation as described by Felsenreich (1934), and sometimes avulsion fracture of the tibial intercondylar eminence (photograph 9).
The tangential patellar projection visualizes the patellofemoral joint and is of importance in differential diagnosis.

V.2.1. Avulsion fractures (photographs 9, 10 and 11)

An avulsion fracture is a fracture caused by traction of a ligament or capsule which has usually remained intact. In 1898 Barth described the avulsion fractures of the tibial intercondylar eminence, and related them to cruciate ligament instability. In the literature, the incidence of avulsion fractures in relation to a ligament lesion is usually not indicated. Liljedahl (1966) found avulsion fractures in 40% of 137 knees in which instability of the anterior cruciate ligament was diagnosed. Dejour (1976) reported 18 avulsion fractures in 40 clinically diagnosed posterior cruciate ligament lesions.



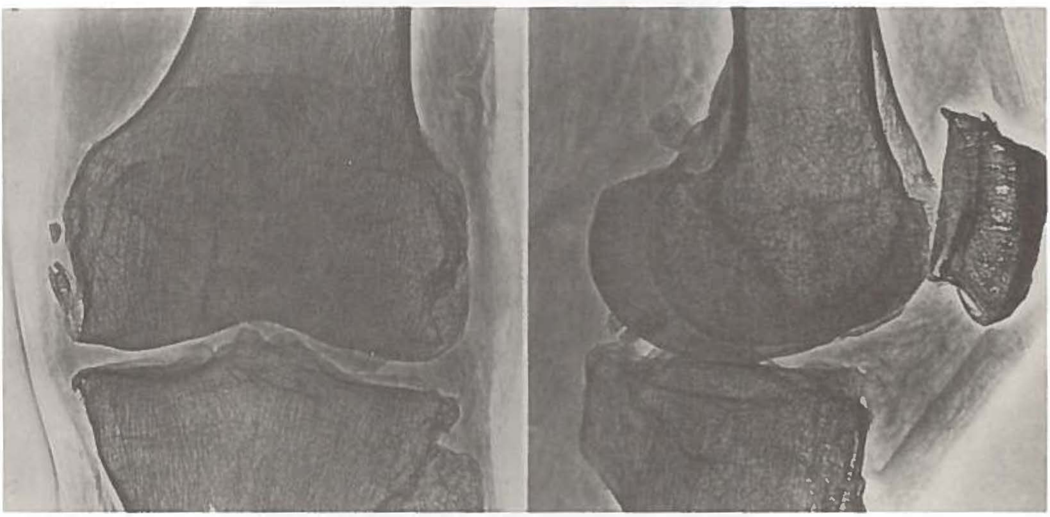
Photograph 9: avulsion fracture of the posterior intercondylar area.

Photograph 10: avulsion fracture of the posterior intercondylar area.

In our series of 83 patients with 87 unstable knees, we found 6 avulsion fractures of the anterior intercondylar, and 9 of the posterior intercondylar area. In the same group, arthrography revealed 4 posterior cruciate ligament lesions, while arthroscopy disclosed 39 anterior ligament lesions.

V.2.2. The Pellegrini-Stieda shadow (photograph 11)

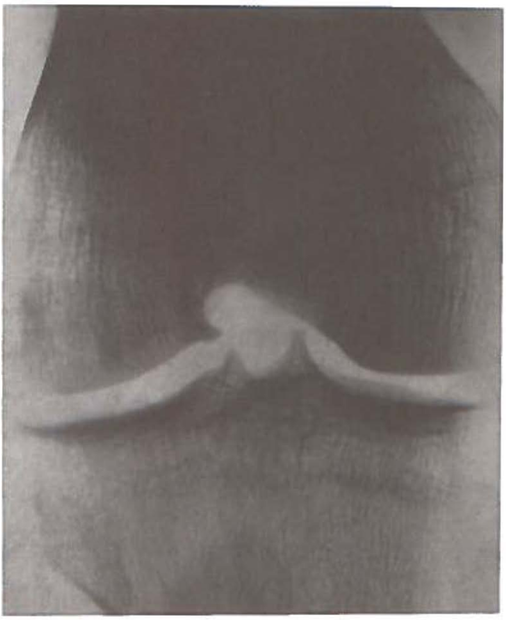
This is a shadow in the soft tissues with the radiolucency of bone, but without its typical structure. As established by Pellegrini in 1905 and by Stieda in 1907, this shadow is an expression of extra-articular bone formation. This shadow has since been described and differently interpreted by several other authors. The majority of these authors agree that this lesion is often observed following a capsular or ligamentous injury. Palmer (1938) observed a Pellegrini-Stieda shadow in 20 of 100 patients with the clinical features of a colateral ligament lesion; it usually developed 3 weeks to 3 mounths after the injury. We found this ossification medial to the femoral condyle in 7, lateral to the femoral condyle in 5, and lateral to the tibial plateau in 2 of the 87 unstable knees we examined. In all cases there was clinical evidence of collateral instability of the knee in flexion.



Photograph 11: avulsion fracture, Pelligrini-Stieda shadow near the medial femoral condyle and spongy deposits on the intercondylar tubercles.

V.2.3. Changes of the tibial eminence (photograph 12)

These changes, described by Felsenreich in 1934, consist of either excessive bone formation (spongy deposits) or bone atrophy (abrasion) at the level of the intercondylar tubercles. They can become visible 9 months to 5 years after an injury of the anterior cruciate ligament. Felsenreich found such changes in 60% of surgically verified anterior cruciate ligament lesions. Palmer (1938) reported similar changes. Comparison between the affected and the unaffected knee is important.
Applying Felsenreich's principles, we analysed the roentgenograms of 79 patients with a total of 83 unstable knees, examined more than 6 months after the injury. We frequently found osteophyte formation or excessive ossification on the tibial eminence and in the intercondylar fossa, usually visible in the affected but not in the unaffected knee. In 4 knees we observed an abrasion of one or both tubercles; 19 knees showed excessive ossification at the level of the anterior intercondylar area, and 33 knees showed unilateral osteophyte formation at the level of the tibilar intercondylar eminence or the femoral intercondylar fossa. The relations between these changes and anterior cruciate ligament lesion, chondropathy of the tibiofemoral joint, meniscal rupture with detached fragment of postmeniscectomy status, as observed at arthroscopy,are shown in table 3.



Photograph 12: **osteophyte fomation on the tibial eminence and in the intercondylar fossa.**

V.3. Arthrography

V.3.1. Technique (photographs 13, 14 and 15)

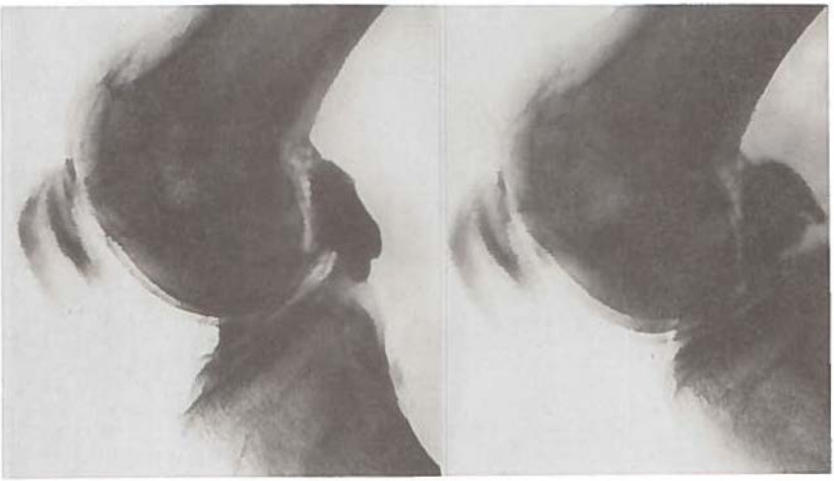
We used the arthrographic technique described by Thijn in 1976. After injection of 5 ml of a 60% tri-iodide solution and 30 ml air, the knee is moved several times and an elastic bandage is placed over the suprapatellar bursa. With the patient sitting, two lateral projections are made with the knee between 60° and 90° flexion. The first exposure is made with the tibia pulled forward, and the second with the tibia pushed back. Next, meniscal and tangenital patellar projections are made by the conventional technique.

V.3.2. Data from the literature

Hoffa (1906) visualized the posterior cruciate ligament in the lateral vieuw with the aid of negative-contrast roentgenography. Lindblom (1938) clearly described the technique of arthrography of the cruciate ligaments and the interpretation. He used positive contrast and a lateral projection. In the case of acute lesions, filling defects were observed on the basis of haematoma formation; in the case of chronic lesions, abnormal deposits of contrast medium were seen at the site of loss of structure. Liljedahl (1966) described several technical refinements of the same technique, by means of lateral projection with the knee in 60-90° flexion and with the tibial plateau pulled forward. In 49 of 52 patients with an anterior cruciate ligament lesion, this was arthrographically demonstrated.

Photograph 13: **arthrographic picture of intact cruciate ligaments.**

Photograph 14: arthrographic picture of a torn anterior cruciate ligament.



Photograph 15: arthrographic picture of a torn posterior cruciate ligament.

Thijn (1976), Nicholas (1970) and others have used the doublecontrast technique in the diagnosis of ligament instability, with varying success.

V.3.3. Arthrographic results

The above described technique was used to obtain 70 arthrograms of the 86 knees with ligament instability. We attempted to establish whether a correlation existed between the tibial displacement and the delimitation of the cruciate ligaments. The data are presented in table 4.
To determine displacement, the two cruciate ligament arthrograms were superposed with the femur congruent, and the displacement of the tibial plateau was measured on the posterior side.
Arthroscopy of 55 knees in this group was performed in addition. A rupture of the anterior cruciate ligament was observed in 32 knees. In 15 of these knees (48%) displacement exeeded 6 mm; and in 23 (72%) the continuity of the anterior cruciate ligament was reported pathological. When both criteria were applied, the positive correlation pathology and ruptured anterior cruciate ligament was 92% (12/13 knees). With the cruciate ligaments intact, displacement exceeded 6 mm in two cases, and continuity was pathological in once case (cf Chapter VII).

V.4. Roentgenography under stress

This study consisted of roentgenography of the knee in the various positions in which various ligaments and part of the knee capsule are stressed. Constant application of force and comparison between affected and unaffected knee are of importance in this respect. Quantitaive determination of instability is possible in this way, and it is also possible to make a critical evaluation of the result of an operation performed for this instability.

V.4.1. Literature

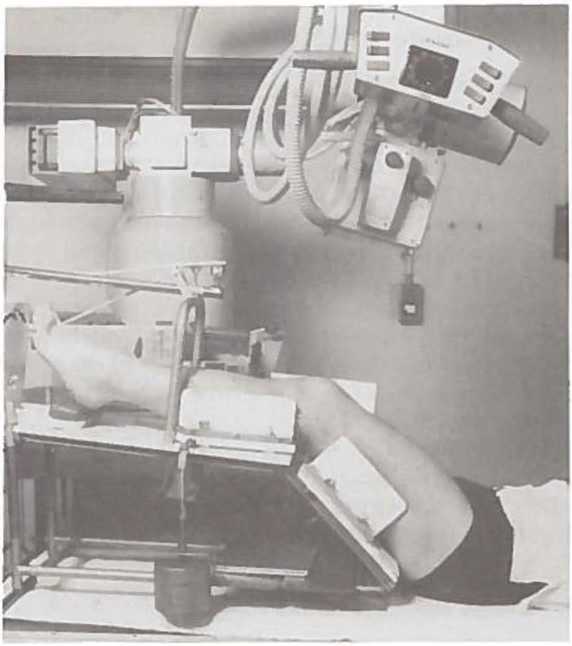
Kennedy (1971) described an excellent stress apparatus with tourniquet-cuff fixation of the thigh, a Freon gas-controlled footplate, and adjustable force of traction with direct reading. The anteroposterior and lateral roentgenograms made before and after traction were superposed, so that displacement could be accurately measured. Anteroposterior instability was demonstrated with the knee in 90° flexion, and lateral instability with the knee in 20° flexion. Kennedy reported a number of normal values and described the clinical application of his method in chronic instability of the knee ligaments. A similar study was subsequently described by Jacobsen (1977), who applied 9 kg traction for lateral and 20-30 kg traction for anterior and posterior displacement. He compared the results of: clinical examination without anaesthesia, roentgenography under stress and under local lanaesthesia, clinical examination under anaesthesia, and peroperative findings in 89 acute lesions of the knee li-

gaments. The correlation between a medial instability of more than 2 mm as compared with the contralateral knee, and a lesion of the medial ligament and/or capsule, was statistically determined.
The accuracy of the roentgenographic examination under stress was comparable with that of clinical examination under anaesthesia and superior to that of clinical examination without anaesthesia.

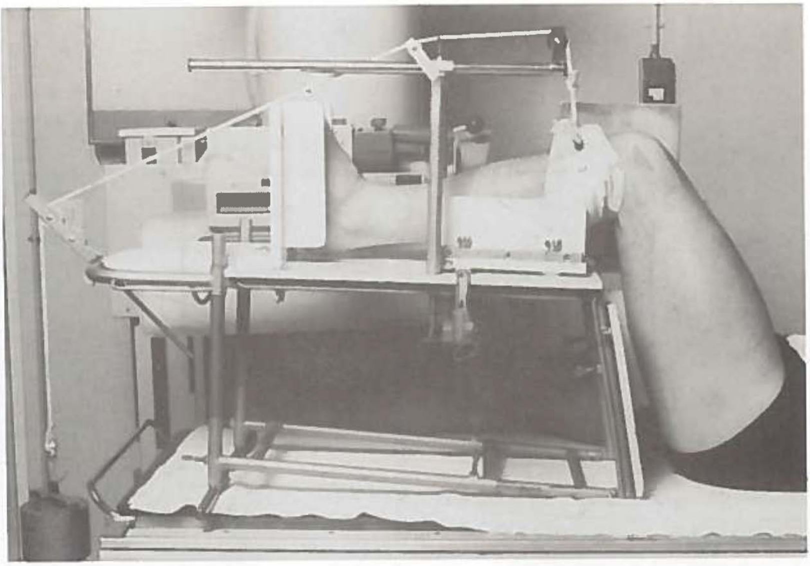
V.4.2. Personal observations: Technical data

In 1975, a simple stress apparatus was developed on the basis of a Braun splint and traction applied by means of a 15 kg weight (cf photograph 16). Six exposures of both knees were made, the total duration of examination being 20 minutes. The distances between focus, object and casette were chosen so that a constant factor of magnification was ensured. The anteroposterior projections were made with the knee in 30° flexion and the beam impinging at an angle of 15°, parallel to the tibial plateau. The examinations were made with the knee in neutral position, under valgus stress and under varus stress. The lateral projections were made with the knee in 90° flexion, the lower leg sagging back under its own weight or pulled forward by means of a cuff. In addition, an exposure was made with the lower leg in maximum exorotation.
Measurements on the roentgenograms were made by superposing two corresponding frames with the distal femoral segment as congruent as possible. Tibial displacement was determined in the anteroposterior view by measuring the tilt of the tibial plateau (medial or lateral), where its projection showed a sharp convex deviation. The lateral shift was measured from the change in position of the posterior aspect of both tibial condyles. The lateral and the medial tibial condyle were identified in the projection in exorotation, where displacement of the various lines could be seen. To establish whether displacement in the lateral view was anterior or posterior displacement, the projections of the two knees were compared. A difference in displacement from the contralateral side of less than 3 mm was regarded as a physiological variation. A difference of 3 mm or more, whether in the anterposterior or in the lateral projection, was regarded as indicative of instability. This liminal value was determined on the basis of data from the literature (e.g. Jacobsen 1976) and on the basis of personal experience in this context. The stability of the medial capsular and ligamentous structures was measured under valgus stress, and that of the lateral capsular and ligamentous structures under varus stress. In the case of an anterior drawer sign, the stability of the anterior cruciate ligament was measured, while in the case of a posterior drawer sign we measured the stability of the posterior cruciate ligament and the posterior part of the knee capsule. The relation between drawer sign and cruciate ligament rupture or instability is discussed in Chapter VII.

(a)



(b)

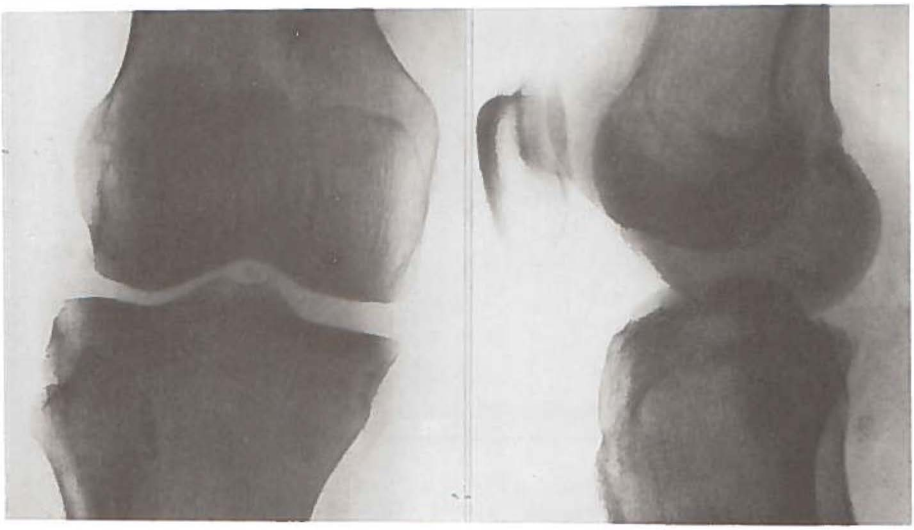


Photograph 16: stress apparatus in function for collateral instability (a) and antero-posterior instability (b) measurments.

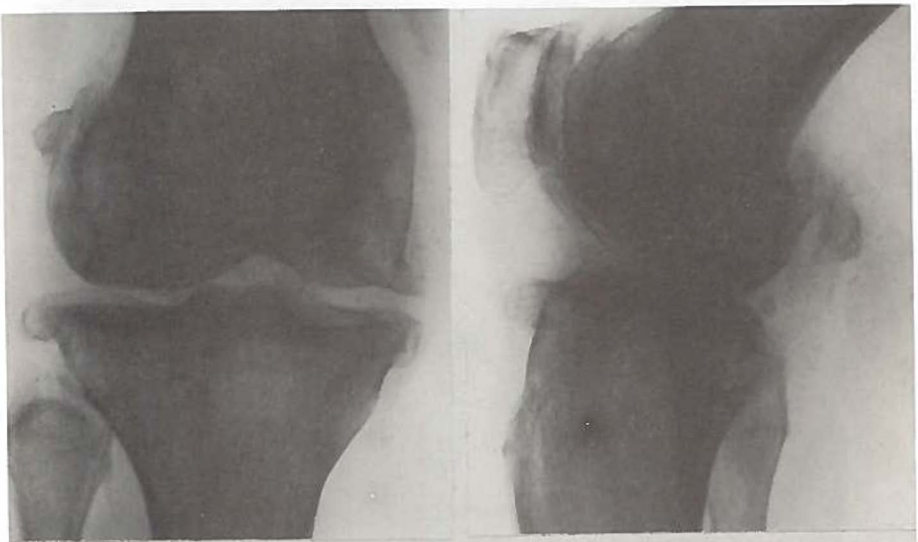
V.4.3. personal observations: Results

In 59 cases, roentgenography under stress was carried out by the above described technique, after a clinical examination. Instability was clinically diagnosed in 63 knees, but radiologically confirmed in only 50 knees. The stable knees showed considerable variance in physiological passive mobility (cf tables 4 and 5). One patient showed a bilateral anteroposterior mobility of 14 and 16 mm, respectively, although the cruciate ligaments were arthrographically and arthroscopically normal. Apart form this patient, 7 mm was the maximum displacement whit intact cruciate ligaments; the maximum collateral displacement with intact ligaments and capsule was 5 mm, with the exception of two patients.
A striking feature noticed during the lateral stress study was abnormal mobility in the sagittal plane. An abnormal translatory movement was visible, as photograph serial 17 show. In one of these patients there was anteromediolateral instability; in another there was a situation after lateral and medial meniscectomy. The classification of instabilities, using the system discussed in Chapter IV and radiologically measured, is presented in table 6. An instructie knee problem is illustrated in photograph serial 18.

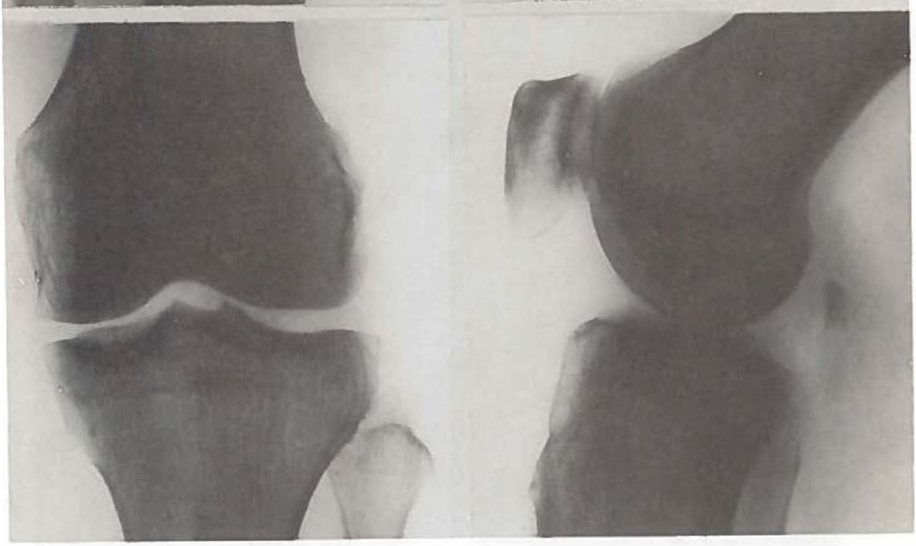
(a)



(b)



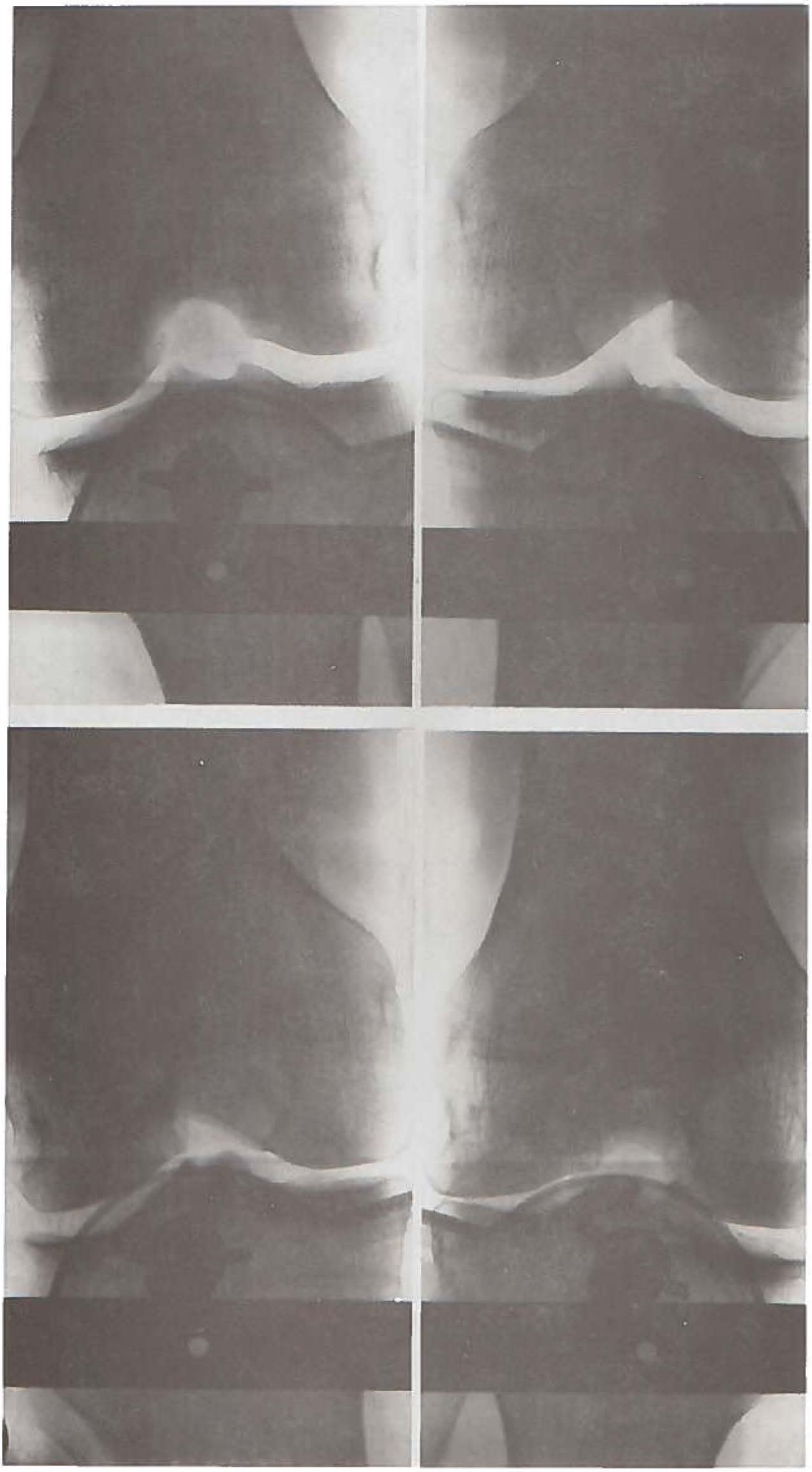
(c)



Photograph 18:
(a) are the roentgenograms taken on the day of trauma. We see the avulsion fractures indicating instability of the posterior cruciate ligament and part of the joint capsule. The patient was treated with plaster of Paris.
(b) are the roentgenograms taken after 20 years of normal use. We see the avulsed fragments, the Pelligrini-Stieda shadow on the lateral side, an ossification at the attachement of the anterior cruciate ligament and the degenerative changes.
(c) are the roentgenograms of the unaffected knee, at the ultimate period.

(a)

(b)



Photograph 17: A.P. stress roentgenograms.
Comparing the normal picture (a) to the pathological one (b) we see the shift in the sagittal plane.

Table 3 - chapter V: ligamental ossification and osteophytes seen in a study of 83 instable knees.

arthroscopic data:	knees with a rupture of the anterior cruciate lig.	knees with tibio-femoral chondropathy	knees after meniscectomie or with a meniscal lesion
34 knees with osteophytes on the tibial eminence of the affected side only	19/34	27/34	19/34
20 knees with ossification above the anterior intercondylar area	19/20	8/20	8/20

Table 4 - chapter V: relation between the drawer sign as measured on the arthrograms and the continuity of the cruciate ligaments.

	displacement		displacement		mean	total
continuity of the cruciate ligaments	1-6 mm	7-12 mm	13-18 mm	18 mm	displacement	arthrograms
intact cruciate ligaments	28	3	2	0	4,4 mm	33
defective contour of the anterior cruciate lig.	11	13	0	0	6,5 mm	24
defective contour of the posterior cruciate lig.	1	4	1	3	13,6 mm	9
defective contour of both cruciate ligaments	0	2	1	1	14,2 mm	4

Table 5 - chapter V

Displacement of the stable and instable knees after correction of the magnification	
A. Values of 68 stable knees: AP views:	med. from 0 to 9 mm (mean 1,7 mm) lat. from 0 to 9 mm (mean 1,9 mm)
LAT. views:	med. from 0 to 15 mm (mean 1,9 mm) lat. from 0 to 16 mm (mean 1,8 mm)
B. Values of 50 instable knees: AP views:	med. from 3 to 9 mm (mean 5,3 mm) lat. from 4 to 15 mm (mean 7,4 mm)
LAT. views: total displ.:	med. from 5 to 21 mm (mean 9,1 mm) lat. from 5 to 20 mm (mean 9,1 mm)
LAT. views: ant. displ.	med. from 3 to 10 mm (mean 6,5 mm) lat. from 3 to 11 mm (mean 6,6 mm)
LAT. views: post. displ.:	med. from 4 to 21 mm (mean 10,6 mm) lat. from 4 to 20 mm (mean 11,3 mm)

Table 6 - chapter V

Diagnosis after roentgenography of 64 knees	
A. Simple instability:	
Medial instability	3
Lateral instability	5
Anterior instability	9
Posterior instability	9
Total	26
B. Compound instability:	
Antero-medial instability	4
Antero-lateral instability	8
Antero-medio-lateral instability	3
Postero-medial instability	2
Postero-lateral instability	2
Antero-posterior instability	1
Antero-postero-medial instability	2
Antero-postero-lateral instability	2
Total	24
C. No ligament instability	14

CHAPTER VI

ARTHROSCOPY

VI.1. Introduction

In 1918, Takagi (Tokyo, Japan) was the first to perform arthroscopy of the knee. After many initial set-backs the method has since developed into an essential aid in the diagnosis of affections of the knee, including internal derangement. The diagnosis of chronic posttraumatic instability of the knee also encompasses the diagnosis of meniscal lesions and chondropathies.
This chapter presents data from the literature on arthroscopy in cases of ligament instability. It also indicates the incidence of meniscal lesions and chrondropathies observed. Is discusses the results of 231 arthroscopies performed in Groningen from 1st March 1975 to 1st March 1978. Arthroscopy has been performed in Groningen since 1969.

VI.2. Data from the literature

Watenabe (1975) found ruptured ligaments in 18 (5.6%) of 320 arthroscopies which he performed during the period 1958-1971. Jackson (1972) found an unmistakable meniscal rupture or a residual detached meniscal fragment in 29% of 200 arthroscopically examined cases; and chondropathic changes in 31%. The findings of Dandy and Jackson (1975) in 174 artroscopies performed on patients with persistent knee symptoms after meniscectomy were: ligamentous lesions in 10%, meniscal lesions in 18%, patellar chondropathy in 45% and tibiofemoral chondropathy in 55%. Smillie (1973) performed 7500 arthrotomies for meniscal lesions and found anterior cruciate ligament lesions in 8.3%. O'Conner (1974) described the arthroscopic features of acute collateral ligament lesions. He stressed the importance of abnormal behaviour of the menisci in rotatory movements and the degree of increasing of the articular space during valgus or varus stress. He found an isolated anterior cruciate ligament lesion in 4 of 21 patients with ligament instability. One had a ruptured lateral meniscus. No chondropathic changes are mentioned in his report.

VI.3. Personal observations

A study was made of 231 arthroscopy records which included data on: history, clinical, radiological and arthrographic findings, pre-arthroscopic findings and the results of arthroscopy (Eikelaar 1975). The knees with posttraumatic ligament instability were given special attention.

Arthroscopy nearly always provides an adequate view of the anterior cruciate ligament. Pathological changes are nearly always visible. In the case of a total anterior cruciate ligament lesion the posterior cruciate ligament is almost entirely visible. With the anterior cruciate ligament intact, however, only the femoral insertion and the proximal one-third of the posterior cruciate ligament can be examined. Increasing of the articular space is a conspicuous feature in collateral ligament instability; likewise, ruptures in the synovial membrane and capsule are visible in the case of an acute ligament lesion.

VI.3.1. Ligament instability

Of the 231 arthroscopies, 68 (29%) revealed posttraumatic ligament instability. The ligamentous changes found are listed in table 7.

VI.3.2. Ligament instability combined with meniscal lesion

In the 231 arthroscopy records we found no difference in incidence of meniscal lesions between the group with and that without instability. But we did find a difference in the number of meniscectomies performed (table 7).

VI.3.3. Ligament instability combined with chondropathy

We had noticed the high incidence of chondropathic changes found at arthroscopy. The relation between the chondropathy and the patient's complaints is not always obvious. But in the case of severe chondropathy this relation exists. We made use of Eikelaar's classification of the severity of chondropathy (3 degrees). Our findings are shown in table 8. Most instances of patellar chondropathy were in association with collateral ligament instability. Chondropahty of the tibiofemoral joint was more frequent in the group with ligament instability than in the control group.

VI.3.4. Other lesions found at arthroscopy

A pendulous fragment of the anterior cruciate ligament was observed in 1 case in this group of patients. It caused limitation of extension. A chondral fracture was found in 1 case in an unstable knee, and in 3 cases in a stable knee. A corpus librum was found in 3 cases in an unstable knee, an in 2 cases in a stable knee.

Table 8 - chapter IV

arthroscopic findings	number of knees		patellar chondropathy					tibio-femoral chondropathy				
	N	%	little	mod.	serious	tot.	%	little	mod.	serious	tot.	%
partial rupture of the anterior cruciate ligament	7	*10*	2	0	0	2	*29*	3	1	0	4	*57*
total rupture of the anterior cruciate ligament	32	*47*	12	4	1	17	*53*	10	4	3	17	*53*
instability of the posterior cruciate ligament	9	*13*	4	0	0	4	*44*	5	1	0	6	*67*
rupture of both cruciate ligaments	2	*3*	0	1	0	1	*50*	1	1	0	2	*100*
collateral instability	18	*27*	10	3	0	13	*72*	4	4	0	8	*44*
total instable knees	68	*100*	28	8	1	37	*54*	23	11	3	37	*54*
stable knees	163	*100*	45	23	10	78	*48*	31	7	9	47	*29*

Table 7 - chapter VI

arthroscopic findings	number of knees	meniscal lesions					performed meniscectomies				
		med.	lat.	both	total	%	med.	lat.	both	total	%
partial rupture of the anterior cruciate ligament	7	2	1	0	3	*43*	1	0	0	1	*14*
total rupture of the anterior cruciate ligament	32	9	5	2	18	*56*	4	2	1	8	*25*
instability of the posterior cruciate ligament	9	0	1	0	1	*11*	0	2	1	4	*44*
rupture of both cruciate ligaments	2	1	0	0	1	*50*	0	0	0	0	*0*
collateral instability	18	5	2	0	7	*39*	0	2	1	4	*22*
total instable knees	68	17	9	2	30	*44*	5	6	3	17	*25*
stable knees	163	39	38	3	83	*51*	7	3	2	14	*9*

Table 9 - Chapter VII value of the drawer sign as a clinical test for instability of the cruciate ligaments. An analysis of 64 knees.

clinical test	number of knees	arthroscopic or roentgenologic findings	number of knees
positive anterior drawer sign	40	normal anterior cruciate ligament	6
		ruptured anterior cruciate ligament	22
		avulsion fracture of the ant. intercond. area [+]	6
		no definite diagnosis	7
negative anterior drawer sign	24	normal anterior cruciate ligament	18
		ruptured anterior cruciate ligament	2
		avulsion fracture of the ant. intercond. area	1
		no definite diagnosis	3
positive posterior drawer sign	20	normal posterior cruciate ligament	4
		ruptured posterior cruciate ligament	7
		avulsion fracture of the post. intercond. area [++]	9
		no definite diagnosis	1
negative posterior drawer sign	44	intact posterior cruciate ligament	44

+ 1 knee presented with a combination of an avulsion fracture and a partial ruptured anterior cruciate ligament.

++ 1 knee presented with a combination of an avulsion fracture and a partial ruptured posterior cruciate ligament.

Table 10 - Chapter VII: value of the antero-posterior displacement as measured on the stress roentgenograms. An analysis of 63 knees. The test was positive when the displacement was 3 mm, compared to the other knee.

roentgenological measuring	number of knees	arthroscopic or roentgenologic findings	number of knees
		normal anterior cruciate ligament	6
		ruptured ant. cruciate lig. or avulsion fracture	22
excessive anterior displacement	33	no definite diagnosis	5
		normal anterior cruciate ligament	17
		ruptured ant. cruciate lig. or avulsion fracture	8
normal anterior displacement	30	no definite diagnosis	5
excessive posterior displacement	18	normal posterior cruciate ligament	2
		ruptured post. cruciate lig. or avulsion fracture	15
		no definite diagnosis	2
normal posterior displacement	45	normal posterior cruciate ligament	45

CHAPTER VII

CONSIDERATIONS

VII.1. Introduction

Every method of investigation has a certain inaccuracy, and a correct diagnosis can only be made by combining several methods. When these methods yield discrepant findings, it is sometimes difficult to establish which finding is correct. It is therefore necessary to test the value and imperfections of each method of investigation used. In comparing our methods of investigation, we had to accept one as the most reliable according to our experience. For the diagnosis of anterior cruciate ligament lesions we accepted as such the data obtained by arthroscopy and/or arthrotomy. For the diagnosis of posterior cruciate ligament lesions we accepted as such: 1) radiological findings (avulsion fracture), 2) arthroscopic findings, and 3) peroperative findings (surgical repair of the posterior cruciate ligament). For the diagnosis of lesions of a collateral ligament and/or capsule we accepted roentgenography under stress as method of reference. The study was done in two groups of patients, as discussed in Chapter I.

VII.2. Anterior drawer sign

a. The drawer sign was studied both clinically (64 knees in 60 patients) and radiologically (63 knees in 59 patients), in an effort to establish a relation between the anterior drawer sign and instability of the anterior cruciate ligament. The results are presented in tables 9 en 10. The clinical diagnosis was erroneous for 8 knees (11%), and the reoentgenographic diagnosis under stress erred for 14 knees (22%). The accuracy of radiological diagnosis of the anterior drawer sign therefore requires improvement. Partly in view of the experience reported by Jacobsen (1977), it might be advisable to increase the traction weight from 15 to 20-30 kg.

b. A positive anterior drawer sign was found at pre-arthroscopic examination in 42 of 231 knees. In 9 of these knees (9/42 x 100% = 21.4%), arthroscopy revealed an intact anterior cruciate ligament. Arthroscopy revealed an anterior cruciate ligament lesion in 9 knees with a negative drawer sign (9/189 x 100% = 4.8%). The relevant data are presented in table 12.

VII.3. Posterior drawer sign

The posterior drawer sign was likewise determined clinically and radiologically. In 4 knees there was a discrepancy between clinical and radiological data. Anteroposterolateral instability was diagnosed in 2 knees, although radiologically there was only anterolateral instability. In 1 knee, anteroposterior instability was clinically diagnosed, but radiologically there was purely posterior instability. One knee (after suture of the medial ligament) presented the clinical features of anteromedial instability, and the radiological features of posterior instability. In the absence of arthrographic or arthroscopic findings in this case, no definite diagnosis could be made. The remaining data are presented in tables 9 an 10.

VII.4. Collateral instability

In the clinical diagnosis of collateral ligament and capsule insufficiency, roentgenography under stress has proved to be a valuable asset. It made it possible to differentiate between medial, lateral and combined collateral ligament insufficiency. It also made it possible to differentiate between primary instability due to a ligament lesion, and secondary instability due to fracture of the tibial plateau or postmeniscectomy status. The correlation between clinical and radiological findings is shown in table 11. In 23 knees, collateral instability was not radiologically demonstrable. In 12 knees there was a postmeniscectomy status or a meniscal lesion with a large luxated fragment. In 4 knees with posterior instability, the collateral instability had been determined, not in the neutral position but with the knee saging backwards. In 4 knees there was anterior instability with abnormal rotation. in 3 knees, no explanation of the discrepancy was found. In 5 knees, a radiologically demonstrable medial (2 knees) and lateral (3 knees) instability was not clinically observed (posterior instability existed in all).

VII.5. Correlation between arthrography and arthroscopy

The study concerned 231 knees, examined both arthrographically and arthroscopically. At arthroscopy the cruciate ligaments were described as intact, totally ruptured or partly ruptured. At arthrography the cruciate ligaments were described as pathological or as non-pathological. In 10 instances the cruciate ligaments were not arthrographically described or could not be evaluated for techical reasons. The data obtained are listed in table 12. In 180 instances the anterior cruciate ligament was described as intact at arthrography, and in 167 knees (93%) this was arthroscopically confirmed. In 41 knees the anterior cruciate ligament was described as patholigical at arthrography, and in 24 (58%) this was confirmed at arthroscopy. In 5 knees with a posterior cruciate ligament lesion diagnosed at arthroscopy, this had already been found at arthrography.

VII.6. Diagnosis based on a combination of several methods

VII.6.1. Introduction

A patient presents with knee symptoms. Physical examination reveals indications of chronic posttraumatic ligament instability. The diagnostic procedure then followed may be illustrated by two examples. The definite diagnoses established in the 64 patients studied are listed in table 13.

VII.6.2. Patients

Patient A was a boy aged 15 at the time of the accident (he ran his moped into a car), in which he sustained multiple injuries including fractures of the left femur and lower leg. The femoral fracture was treated by open reduction and stabilized by osteosynthesis. The fracture of the lower leg was treated conservatively. The fractures healed without problems, but the patient continued to complain about his left knee: recurrent hydrops, sagging, pain under stress and during sagging. He was unable to resume his work as a butcher. Orthopaedic examination one year after the accident led to a diagnosis of instability of the posterior cruciate ligament on the basis of an avulsion fracture (cf phogograph 10). Arthrograpy revealed: pathology of both cruciate ligaments, intact menisci, intact patellar cartilage. Roentgenography under stress revealed posterolateral instability with posterior displacement up to 18 mm and lateral deviation up to 4 mm as compared with the intact leg. Arthroscopy revealed a normal anterior cruciate ligament and a normal femoral insertion of the posterior cruciate ligament. There was little chondropathy of the patella, femoral intercondylar fossa and lateral tibial plateau. The menisci were intact. Adequate therapy could then be instituted.
Patient B was a man aged 25 at the time of the accident (he „went through'' the right knee while playing football). The knee started swelling almost immediately. No instability was demonstrable, and exercise therapy was instituted. However, he continued to complain about the knee: recurrent hydrops, sagging, fatigue and pain at extension. The symptoms impaired his activities at work and in sports. Clinical examination revealed an abbreviated standing phase, disturbed hopping, a positive anterior drawer sign which attained its maximum in the indifferent postion but was present also with the tibia in endorotation, and a positive pivot shift test. Arthrography revealed pathology of the anterior cruciate ligament and a ruptured medial meniscus. Roentgenography under stress failed to reveal instability. Arthroscopy revealed synovitis, total rupture of the anterior cruciate ligament, intact menisci and intact cartilage. The cause of the patient's complaints, therefore, was anterolateral rotatory instability. Adequate therapy could be instituted on the basis of this diagnosis.

Table 11 - Chapter VII: collateral instability, relation between the clinical and roentgenological tests.

clinical stress test	number of knees	roentgenological stress test	number of knees
		medial instability	3
		lateral instability	0
medial instability	5	medial and lateral instability	1
		no instability	1
		medial instability	1
		lateral instability	4
lateral instability	12	medial and lateral instability	1
		no instability	6
		medial instability	5
		lateral instability	10
collateral instability	32	medial and lateral instability	1
		no instability	16
total	49	total	49

Table 12 - Chapter VII: arthroscopic and arthrographic diagnosis of the anterior cruciate ligament; an analysis of 231 knees.

arthroscopy	number of knees	arthrography	number of knees
intact ligament	190	intact ligament	167
		pathological ligament	17
		no definite diagnosis	6
total rupture of the ligament	33	intact ligament	10
		pathological ligament	21
		no definite diagnosis	2
partial rupture of the ligament	8	intact ligament	3
		pathological ligament	3
		no definite diagnosis	2

Table 13 -chapter VII

Final diagnosis of 64 knees	
A. Simple instability:	
Medial instability	3
Lateral instability	3
Anterior instability	14
Posterior instability	8
Total	28
B. Compound instability:	
Antero-medial instability	4
Antero-lateral instability	10
Antero-medio-lateral instability	3
Postero-medial instability	2
Postero-lateral instability	2
Antero-posterior instability	1
Antero-postero-medial instability	2
Antero-postero-lateral instability	2
Total	26
C. No ligament instability	10

CHAPTER VIII

SUMMARY AND CONCLUSIONS

VIII.1. Summary

The purpose of this thesis is to improve our insight into the diagnosis of chronic posttraumatic instability of the knee. The mechanics of the knee-joint are essential in this respect. Insight into the functioning of the knee-joint improves our understanding of functional disorders of the knee. The diagnosis of chronic instability of the knee ligaments remains difficult. in most cases an accurate diagnosis can only be made on the basis of a combination of several methods of investigation.

Chapter I presents a survey of the pertinent literature and a definition of the objectives of this thesis.

Chapter II gives a brief description of the anatomy of the knee-joint with capsule, ligaments and muscalature.

Chapter III discusses some principles of the kinematics and dynamics of the knee-joint. The flexion-extension movement as projected in the sagittal plane has been discussed in many studies. A number of authors have studied the rotatory component of this movement or, rather, the projection of this movement in the transverse plane. We studied the flexion-extension movement as projected in the frontal plane.
A study of two knees under physiological stress reveals a rotatory movement with a total angle of 3.5° and 5°. The voluntary (adjunct) rotation of the knee-joint in anatomical specimens is analysed. In all knees the rotation axis proves to change its position, indicating a combination of rotatory and translatory movements. The evolute obtained differs per specimen in localization and shape, bus is usually localized around or medial to the tibial intercondylar eminence. This evolute changes its shape as flexion changes, when ligaments are severed, and when valgus or varus stress is induced.

Chapter IV discusses the anamnesis and examination of the stressed and unstressed knee for instability of the knee-joint. It also presents the clinical data on 60 patients with posttraumatic instability of one or both knees.

Chapter V discusses radiological examinations with and without contrast medium. Avulsion fracture, the Pellegrini-Stieda shadow, hook formation and excessive ossification receive special attention. In the group of patients studied, a relation is established between excessive ossification at the level of the anterior tibial intercondylar area and an anterior cruciate ligament lesion, and between osteophyte formation on the tibial intercondylar eminence and chondropathy of the tibiofemoral joint. Arthrography of the cruciate ligaments in the presence of an anterior and a posterior drawer sign is discussed. Important features are the continuity of the cruciate ligaments and the shift of the tibial plateau in relation to the femoral condyles. This chapter also discusses roentgenorgraphy under stress, with reference to the literature and to personal observations with the aid of a simple constant-traction stress apparatus.

Chapter VI discusses the arthroscopic features of chronic instability of the knee. Arthroscopy provides information on the menisci, cartilage and both cruciate ligaments. The data obtained by 231 arthroscopies are discussed: 68 unstable knees were diagnosed, with anterior cruciate ligament lesions in 41. A comparison is made of the indices of meniscal lesions and chrondropathy in the group with and that without ligament instability. No difference in the number of meniscal lesions is found, but the number of previous meniscectomies differs in the two groups. Chondropathy of the tibiofemoral joint is more frequently observed in the group with ligament instability; a high incidence of chondropathy of the patellofemoral joint is found only in the presence of collateral ligament instability.

Chapger VII presents considerations on the study and its findings. An accurate diagnosis of instability of the knee can usually be established with the aid of several combined diagnostic techniques. This is illustrated by two examples.

VIII.2. Conclusions

An attempt can now be made to answer the questions posed in Chapter I:

1. What is the value of adequate clinical examination in the diagnosis of instability of the knee?

There is a close but not an absolute correlation between drawer sign and cruciate ligament lesion. Differentiation between anterior and posterior drawer sign is usually possible by comparing the two knees. Collateral instability, too, should be determined with the knee in flexion. Differentiation between medial and lateral instability is difficult, and it is virtually impossible to differentiate between instability due to increased space (meniscectomy, absence of cartilage, fracture of the tibial plateau) and ligament instability. Clinical quantification of an instability is usually impossible.

2. What is the value of routine radiological examination in the diagnosis of ligament instability?

Roentgenograms without contrast medium usually fail to reveal the lesions. However, we found an avulsion fracture of the posterior or anterior intercondylar area in 15, a Pellegrini-Stieda shadow in 12, and excessive ossification on the anterior aspect of the medial tibial intercondylar tubercle in 19 of 87 unstable knees examined. In 33 knees, osteophyte formation on the eminence or in the femoral intercondylar fossa was suggestive of chondropathy of the tibiofemoral joint.

3. What is the value of arthrography in the diagnosis of cruciate ligament lesions?

Arthrography has become a routine procedure in the case of internal derangement of the knee. It is surprising that arthrography of the cruciate ligaments has not become more widely known. Expansion of the examination by adding two cruciate ligament exposures can hardly distress the patient or the investigator. Interpretation of the arthrographic features is not more difficult than that of meniscal ruptures. In the group studied, however, the accuracy or arthrography was 58%, with in some cases an accuracy of 92%. The continuity of the cruciate ligaments and the shift of the tibia in relation to the femur are important.

4. What is the value of roentgenography under stress in the diagnosis of instability of the knee?

Roentgenography under stress is another method of investigation which has failed to become widely known. Perhaps the construction of an expensive stress apparatus is prohibitive. A Braun splint modified for this purpose, however, serves quite well. This construction can be varied or perfected. However, certain principles are of importance in this respect, as indicated in the relevant chapter.

Roentgenography under stress makes it possible to diagnose and quantify instability. Differentiation between anterior, posterior, lateral and medial instability or a combination of these types is quite readily possible. Roentgenography under stress should always precede surgical reconstruction or repair of a ligament.

5. What are the social consequences of chronic posttraumatic instability of the knee?

This condition is usually found in young, muscular individuals, and prevents them from doing their work or practising their sport. Of the 60 clinically studied patients, only 24 have fully resumed work, 22 have been declared unfit, and 5 have changed their occupation. The remaining patients were either at school or housewives. Of the 12 active sportsmen, 9 were unable to resume these activities.

Final conclusion

The diagnosis of instability of the knee is an indispensable component of the diagnosis of internal derangement of the knee-joint. The most accurate diagnosis of chronic posttraumatic instability of the knee is a first step towards adequate therapy.

SAMENVATTING EN CONCLUSIES

I. Samenvatting.

Dit proefschrift heeft als doel een beter inzicht te verkrijgen in de diagnostiek van de chronische post-traumatische kniebandinstabiliteit. De mechanica van het kniegewricht is in deze een essentiëel onderdeel. Door inzicht in het functioneren van dit gewricht is het mogelijk een beter begrip te krijgen van de kniefunctiestoornissen. De diagnostiek van de chronische kniebandinstabiliteit blijkt moeilijk. Een nauwkeurige diagnose is in de meeste gevallen alleen mogelijk door een combinatie van verschillende onderzoekmethodes.

In hoofdstuk I wordt een overzicht gegeven betreffende de literatuur die handelt over dit onderwerp. Tevens wordt de doelstelling van dit proefschrift nader omschreven.

In hoofdstu»k II wordt een korte beschrijving gegeven van de anatomie van het kniegewricht.

In hoofdstuk III worden enkele principes betreffende de kinematica en de dynamica van het kniegewricht besproken. Bekend is de flexie-extensiebeweging, zoals deze geprojecteerd wordt in het sagittale vlak. De rotatiecomponent van deze beweging of anders gezegd de projectie van deze beweging in het transversale vlak is door een aantal schrijvers bestudeerd. Door ons is bestudeerd de flexie-extensiebeweging zoals deze zich projecteert in het frontale vlak. Volgens een studie van twee normaal belaste knieën, blijkt er sprake te zijn van een rotatiebeweging met een totale hoek van respectievelijk 3,5° en 5°. Aan de hand van anatomische preparaten wordt de willekeurige rotatie van het kniegewricht geanalyseerd.
De rotatie-as blijkt bij alle knieën van plaats te veranderen, wijzend op een combinatie van rotatie- en translatiebewegingen.
De verkregen evolute is per preparaat verschillend in plaats en vorm, echter meestal gelocaliseerd rond of mediaal van de eminentia intercondylaris tibiae.
Deze evolute verandert ook van vorm bij verandering van de flexiestand, bij het doorsnijden van banden alsmede bij een geïnduceerde valgus- of varusstress.

In hoofdstuk IV wordt de anamnese, het belaste en het onbelaste knieonderzoek gericht op de instabiliteit van het kniegewricht besproken. Tevens worden weergegeven de klinische gegevens van zestig patiënten met het beeld van één of soms twee instabiele knieën als gevolg van een trauma.

In hoofdstuk V wordt het röntgenologisch onderzoek zonder en met contrast besproken.
Gelet is op de avulsiefracturen, de Pellegrini Stieda schaduw, de haakvorming en extra botaanmaak.
In de bestudeerde groep patiënten blijkt een relatie aanwezig tussen extra botaanmaak ter hoogte van de area intercondylaris anterior tibiae en een voorste kruisbandlaesie alsook tussen haakvorming aan de eminentia intercondylaris tibiae en een chondropathie van het tibiofemorale gewricht.
De arthrografie van de kruisbanden verricht met het ladenverschijnsel naar voren en naar achteren wordt besproken.
Belangrijk zijn de continuïteit van de ,kruisbanden en de verschuiving van het tibiaplateau ten opzichte van de femurcondylen.
Tevens wordt het röntgenologisch stressonderzoek besproken waarbij literatuurgegevens en eigen onderzoek op een eenvoudig apparaat met een constante tractie zijn weergegeven.

Hoofdstuk VI belicht de arthroscopie van de chronisch instabiele knie.
De arthroscopie in ervaren handen geeft ons informatie over de menisci, het kraakbeen en beide kruisbanden. De gegevens van 231 arthroscopieën worden besproken.
Gediagnostiseerd zijn 68 instabiele knieën waarbij 41 voorste kruisbandlaesies.
In vergelijking met de groep stabiele knieën blijkt er in de groep met instabiele knieën een gelijke frequentie meniscusscheuren, een verhoogde frequentie menisectomieën, een verhoogde frequentie tibiofemorale chondropathie, een licht verhoogde frequentie patellofemorale chondropathie.
Een duidelijk verhoogde frequentie patellofemorale chondropathie werd gezien bij de knieën met een enkelvoudige collaterale bandinstabiliteit.

Hoofdstuk VII bevat een beschouwing betreffende het onderzoek. Door het tegelijkertijd toepassen van verschillende diagnostische technieken bij een instabiele knie is het meestal mogelijk tot een nauwkeurige diagnose te komen. Dit wordt toegelicht aan de hand van twee ziektegeschiedenissen.

II. Conclusies.

Wij zullen trachten een antwoord te geven op de in hoofdstuk I gestelde vragen:

1. Wat is de waarde van een goed klinisch onderzoek voor de diagnostiek van de instabiele knie?

Er is een goede doch geen absolute correlatie tussen het ladenverschijnsel en een kruisbandlaesie.

Een differentiatie tussen het ladenverschijnsel naar achteren en naar voren is meestal duidelijk bij een vergelijkend onderzoek van beide knieën.
De collaterale instabiliteit dient ook bepaald te worden met de knie in flexiestand.
De differentiatie tussen een mediale en een laterale instabiliteit blijft moeilijk, terwijl een differentiatie tussen instabiliteit door een toegenomen ruimte (menisectomie, afwezigheid van kraakbeen, tibiaplateaufractuur) of door een bandinstabiliteit vrijwel onmogelijk is.
Het klinisch kwantificeren van een instabiliteit is meestal niet mogelijk.

2. Wat is de waarde van het routine röntgenonderzoek bij een bandinstabiliteit?

De röntgenfoto's zonder contrast zullen in de meeste gevallen geen afwijkingen tonen.
Echter bij de bestudeerde 86 instabiele knieën is 15 maal een avulsiefractuur van de area intercondylaris posterior of anterior gevonden, 14 maal een Pellegrini Stieda schaduw en 19 maal een overmatige botvorming aan de voorzijde van het tuberculum intercondylare mediale tibiae als aanwijzing voor een voorste kruisbandlaesie.
Bij 33 knieën is haakvorming, gezien aan de eminentie of in de poort, een mogelijke aanwijzing voor een chondropathie van het tibiofemorale gewricht.

3. Wat is de waarde van de arthrografie bij de kruisbandlaesie?

De arthrografie is een routine procedure geworden bij een dérangement interne van het kniegewricht.
Het is merkwaardig dat de arthrografie van de kruisbanden zo weinig bekendheid heeft gekregen.
De uitbreiding van het onderzoek met twee kruisbandopnames is een zeer geringe belasting voor patiënt en röntgenoloog.
De interpretatie van de beelden is niet moeilijker dan die van meniscusscheuren.
In de bestudeerde groep was de nauwkeurigheid van de arthrografie bij pathologie van de voorste kruisband 58%, met in een aantal gevallen een nauwkeeurigheid van 92%.

4. Wat is de waarde van het röntgenologisch stressonderzoek bij de instabiele knie?

Ook het röntgenologisch stressonderzoek heeft over het algemeen weinig bekendheid gekregen.
Mogelijkerwijs is de constructie van een kostbaar stressapparaat een drempel.
Een omgebouwde Braunse spalk blijkt voor die doel echter goed bruikbaar. Een variatie of perfectioneren van deze constructie is mogelijk indien men zich houdt aan een aantal principes zoals dit aangegeven is in het betreffende hoofdstuk.

— Bij dit röntgenologisch onderzoek is het mogelijk een instabiliteit vast te leggen en te kwantificeren en direct te differentiëren tussen een instabiliteit door een toegenomen intra-articulaire ruimte of door bandslapte.
  Een nauwkeurige bepaling van het instabiliteitstype is gemakkelijk. Alleen de zuiver rotatoire instabiliteit ontsnapt aan deze analyse.
— Een röntgenologisch stressonderzoek dient vooraf te gaan aan elke reconstructie of bandplastiek.

5. Wat zijn de sociale gevolgen van een chronische post-traumatische bandinstabiliteit?

Deze afwijking treft meestal jonge, gespierde mensen.
Door deze afwijking kunnen betrokkenen vaak hun werk en meestal het sporten niet meer verrichten.
Van de 60 klinisch bestudeerde patiënten werkten slechts 24 voor 100%, waren 22 arbeidsongeschikt en bleken 5 van beroep veranderd.
De overige waren scholier of huisvrouw.
Van de 12 actieve sportbeoefenaars konden 9 niet meer sporten.

III. Slotconclusie.

De diagnostiek van de instabiele knie is een onmisbaar onderdeel van de diagnostiek van het dérangement interne van het kniegewricht.
Een zo volledig mogelijke diagnostiek van de chronische post-traumatische kniebandinstabiliteit is de eerste stap naar de meest adequate behandeling.

RIASSUNTO E CONCLUSIONE

I. Riassunto.

Questa pubblicazione ha lo scopo di darci una migliore conoscenza circa la diagnosi della rilassatezza cronica post traumatica del ginocchio. Lo studio della fisiologia del ginocchio ne è una parte essenziale. Conoscendo il funzionamento di questa articolazione è possibile capire meglio le cause dello squilibrio. Non si può arrivare ad una diagnosi precisa della instabilità cronica del ginocchio, senza usare i risultati di tecniche diverse.

Il primo capitolo dà una visione generale della letteratura su questo argomento e precisa lo scopo di questa tesi.

Il secondo capitolo è un compendio dell'anatomia descrittiva e funzionale del ginocchio.

Nel terzo capitolo vengono discussi taluni principi della meccanica del ginocchio. Sono già conosciute la proiezione del movimento di flessione e di estensione sul piano sagittale e la rotazione che accompagna tale movimento.
Attraverso uno studio di due ginocchi sotto carico, noi abbiamo studiato la proiezione di questo movimento sul piano frontale, arrivando alla conclusione che si tratta di un movimento di rotazione con un angolo totale di 3,5° e di 5°. Abbiamo analizzato il movimento di rotazione volontaria attraverso due studi su ginocchi del laboratorio anatomico. Ne abbiamo concluso che l'asse di rotazione non è fisso ma forma una curva chiamata da Fick ,,evolute''. Il movimento è, quindi, una combinazione di rotazione e translazione.
L',,evolute'' non ha una forma costante, ma è generalmente localizzata intorno o appena all'interno delle spine tibiali. La forma e la localizzazione di tale curva variano anche nelle diverse fasi di flessione del ginocchio, dopo sezione dei legamenti o dopo sollecitazione della tibia in valgo o in varo.

Il quarto capitolo riporta l'analisi clinica della rilassatezza del ginocchio. Vi è riferita la diagnosi clinica su 64 ginocchi instabili di 60 pazienti.

Il quinto capitolo analizza la radiografia standard, a doppio contrasto e in stato di stress.
Nella radiografia standard si ricercano il distacco delle spine tibiali,le ossificazioni nei legamenti e la formazione di osteofiti.
Nel gruppo dei pazienti studiati abbiamo trovato una relazione tra le macchie di calcificazione al livello della superficie prespinale ed una rottura del legamento crociato anteriore.Abbiamo trovato conferma alla relazione esistente fra la formazione di osteofiti alle spine tibiali ed una

condromalacia dell'articolazione tibio-femorale. Viene analizzata l'artrografia dei legamenti crociati, fatta in cassetto anteriore e posteriore. Si deve riconoscere la continuità dei legamenti e misurare lo spostamento della tibia rispetto al femore.
La radiografia in stress comprende la radiografia dei due ginocchi in valgo, in varo, in cassetto anteriore e posteriore. Vi sono riportate la letteratura in merito ed una personale ricerca su un attrezzo di trazione.

Il sesto capitolo ci mostra l'importanza dell'artroscopia nelle lassità croniche del ginocchio. Utilizzata da mani esperte ci informa sullo stato del menisco, della cartilagine e dei legamenti crociati.
Vengono discussi i dati di 231 artroscopie. Vi sono diagnosticati 68 ginocchi instabili, 41 dei quali con una rottura del legamento crociato anteriore.
Confrontato con il gruppo dei ginocchi stabili, si ritrova nel gruppo di quelli instabili la stessa quantità di rotture del menisco ma una maggiore frequenza di meniscectomia, di condromalacia tibio-femorale e di condromalacia della rotula.
Nei ginocchi a instabilità collaterale semplice questa alta frequenza di condromalacia rotulare è piú evidente.

Il settimo capitolo analizza diversi metodi diagnostici usati, confrontandoli. E quasi sempre possibile giungere ad una analisi precisa per mezzo dell'esame clinico, delle varie tecniche radiologiche e dell'artroscopia. Due esempi chiariscono questa tecnica di ricerca.

II. Conclusioni.

Cercheremo di rispondere ai quesiti posti nel primo capitolo.

1. Quale è il valore dell'esame clinico nella diagnosi della rilassatezza del ginocchio?

Sussiste una buona ma non assoluta correlazione fra il sintomo del cassetto anteriore o posteriore ed una rottura del legamento crociato anteriore o posteriore.
E possibile, in genere, differenziare il cassetto anteriore da quello posteriore sottoponendo i due ginocchi ad una ricerca identica.
La diagnosi di instabilità collaterale si fa col ginocchio in posizione di estensione e di flessione.
Resta difficile differenziare una instabilità mediale da una laterale. E spesso impossibile fare la differenza tra una instabilità per aumento dello spazio articolare (meniscectomia, artrosi, frattura del piatto tibiale) ed una per insufficienza legamentare, come anche stabilire l'ampiezza di una instabilità.

2. Qual'è il valore della radiografia standard nella instabilità legamentare del ginocchio?

Nella maggior parte dei casi le radiografie non presentano alcuna anormalità. Eppure, negli 86 ginocchi instabili studiati, noi abbiamo trovato 14 casi di ossificazione di Pellegrini-Stieda, 19 casi di macchie di ossificazione al livello della superficie prespinale, 33 casi di osteofite alla tibia e al femore.

3. Qual'è il valore dell'artrografia nella diagnosi dei legamenti crociati?

L'artrografia del ginocchio è divenuta una routine nella diagnosi dei disturbi interni. E sorprendente come sia poco diffusa l'artrografia dei legamenti crociati. Nel gruppo studiato, la relazione positiva tra patologia e rottura del crociato anteriore era del 58% con possibilità di raggiungere, in certi casi, il 92%.

4. Qual'è il valore della radiografia in stress?

Anche questa tecnica radiologica è poco usata. Forse un impianto costoso sarebbe difficilmente realizzabile. Noi abbiamo utilizzato, modificandolo, un attrezzo di trazione di Braun. Ulteriori modifiche o perfezionamenti sono possibili dal momento che vengano osservati alcuni principi. Con questa tecnica diventa possibile determinare il tipo di instabilità, fissarne e stabilirne l'ampiezza. Sfugge a questa analisi solo l'instabilità rotatoria pura.
La radiografia in stress dovrebbe precedere ogni ricostruzione dei legamenti.

5. Quali sono le conseguenze sociali di una instabilità cronica posttraumatica?

Questa rilassatezza si riscontra generalmente nei giovani dai muscoli sviluppati. E spesso difficile continuare a lavorare come impossibile, in molti casi, praticare dello sport.
Tra i pazienti studiati, solo 24 lavorano al 100%, 22 sono incapaci di lavorare, 5 hanno cambiato tipo di attività, gli altri sono studenti o casalinghe. Dei 12 pazienti sportivi, 9 non possono piú dedicarsi allo sport.

III. Conclusione finale.

L'analisi della rilassatezza del ginocchio è un elemento essenziale alla diagnosi dei disturbi interni.
Una diagnosi precisa e completa è l'inizio di una terapia adeguata.

RÉSUME ET CONCLUSIONS

I. Résumé.

Cette thèse a comme but de nous donner une meilleure connaissance du diagnostic des laxités post traumatiques anciennes du genbou. L'étude de la physiologie du genou en est une partie essentielle. En connaissant le fonctionnement de cette articulation, il est possible de mieux comprendre les causes de déséquilibre. Le diagnostic d'une laxité ancienne du genou est difficile.
Pour arriver à un diagnostic précis il est nécessaire de réunir des techniques diverses.

Le premier chapitre donne une vue générale de la littérature à ce sujet. Le but de cette thèse est précisé.

Le second chapitre donne un aperçu de l'anatomie descriptive et fonctionnelle du genou.

Dans le troisième chapitre certains principes du mécanisme du genoiu sont discutés.
La projection du mouvement de fléxion et d'éxtension dans le plan sagittal est connue. Le mouvement de rotation qui accompagne ce mouvement a été étudié par divers auteurs.
Nous avons étudié la projection de ce mouvement dans le plan frontal. A travers une étude de deux genoux sous pression, nous avons conclu qu'il s'agit d'un mouvement de rotation avec un angle de 3,5° et de 5°. Nous avons analysé le mouvement de rotation volontaire au moyen de deux études sur des genoux préparés.
Nous avons conclu que l'axe de rotation n'est pas fixe, mais forme une „evolute". Le mouvement est donc une combinaison de rotation et de translation. „L'évolute" n'a pas une forme constante mais est généralement localisée autour ou juste à la partie interne des épines tibiales. La forme et la localisation sont aussi variables dans les différentes phases de flexion du genou, après section de ligaments ou après déplacement du tibia en valgus ou en varus.

Le quatrième chapitre est un rappel du diagnostic clinique des laxités du genou. Le diagnostic clinique de 64 genoux instables chez 60 patients est rapporté.

Le cinquième chapitre est une analyse du diagnostic radiologique standard, à double contraste et en stress.
Dans la radiographie standard on recherche les arrachements osseux, les ossifications ligamentaires et la formation d'ostéophytes. Dans le groupe de patients étudiés nous avons trouvé une relation entre des taches d'ossification au niveau de la surface préspinale et une rupture du ligament croisé anterieur.

Nous avons eu confirmation de la relation entre la formation d'ostéophytes aux épines tibiales et une chondromalacie de l'articulation tibiofémorale.
L'arthrographie des ligaments croisés, faite en tiroir antérieur et postérieur est analysé. On doit reconnaître la continuité des ligaments et déterminer le déplacement du tibia par rapport au fémur.
La radiographie en stress comprend la radiographie des deux genoux en valgus et varus forcé ainsi qu'en tiroir antérieur et postérieur. La littérature á ce sujet et une recherche personnelle sur un appareil de traction sont rapportés.

Le sixième chapitre nous montre l'importance de l'arthroscopie dans les laxités anciennes du genou. Dans des mains expérimentées, elle nous informe de l'état des ménisques, du cartilage et des ligaments croisés.
Les données de 231 arthroscopies sont discutées. On a diagnostiqué 68 genoux instables dont 41 avec une rupture du ligament croisé anterieur. Comparé au groupe des genoux stables il y a dans le groupe de genoux instables une fréquence égale de ruptures meniscales, une fréquence plus élevée de menisectomies, une fréquence plus élevée de chondromalacies tibio-fémorales et une fréquence légèrement plus élevée de chondromalacies patellaires.
Une haute fréquence de chondromalacies patellaires est trouvée dans les genoux avec une instabilité collatérale simple.

Le septième chapitre donne une analyse des différentes méthodes employées en comparant l'une à l'autre.
Avec la combinaison de l'examen clinique, des différentes techniques radiologiques et de l'arthroscopie il est presque toujours possible d'arriver à un diagnostic précis. Deux exemples éclaircissent cette technique de recherche.

II. Conclusions.

Nous chercherons à répondre aux questions posées le premier chapitre.

1. Quelle est la valeur de l'examen clinique dans le diagnostic de la laxité du genou?

Entre le symptôme du tiroir antérieur ou postérieur et une rupture du ligament croisé antérieur ou postérieur la corrélation est bonne, mais pas absolue. Différencier le tiroir antérieur et postérieur est en général possible, en amenant les deux genoux dans une situation de recherche identique.
Le diagnostic de l'instabilité collatérale se fait avec le genou en extension et en flexion.
Différencier une instabilité interne d'une instabilité externe reste difficile. Faire la différence d'une instabilité par augmentation de l'espace articulaire (menisectomie, arthrose, fracture du plateau tibial) et d'une laxité ligamentaire ou doser une instabilité est souvent impossible.

2. Quelle est la valeur de la radiographie standard dans l'i'nstabilité ligamentaire du genou?

Dans la plupart des cas, les radiographies ne montrent aucune anomalie. Cependant chez les 86 genoux instables étudiés, nous avons vu 15 fois un arrachement osseux, 14 fois une ossification de Pellegrini-Stieda, 19 fois des taches d'ossification au niveau de la surface préspinale, 33 fois des ostéophytes au niveau des épines tibiales ou de l'échancrure intercondylienne du femur.

3. Quelle est la valeur de l'arthrographie des ligaments croisés?

L'arthrographie est devenue une routine dans le diagnostic des dérangements internes. Il est étonnant que l'arthrographie des ligaments croisés est si peu connue. La corrélation positive entre pathologie et rupture du ligament croisé anterieur était dans le groupe étudié de 58% et dans certains cas de 92%.

4. Quelle est la valeur des radiographies en stress?

Il est difficile à dire pourquoi cette technique radiologique est peu employée. Il est possible que la construction d'un appareil coûteux forme un seuil difficile à franchir. Nous avons utilisé un appareil de traction selon Braun, quelque peu modifié.
D'autres modifications ou perfectionements sont possibles, du moment que certains principes sont observés.
Avec cette technique il est possible de déterminer, de fixer et de doser une instabilité du genou.
On peut directement différencier entre une instabilité par augmentation de l'espace articulaire et une instabilité par laxité, tandis qu'une spécification précise du type d'instabilité est simple.
Seule l'instabilité rotatoire pure échappe à cette analyse radiologique.
La radiographie en stress devrait précéder toute reconstruction ligamentaire.

5. Quelles sont les conséquences sociales d'une instabilité chronique post-traumatique?

Cette laxité concerne en général de jeunes gens musclés. Continuer à travailler est fréquemment difficile, faire du sport souvent impossible.
Des 60 patients étudiés, seul 24 font leur travail à 100%, 22 sont incapables de travailler, 5 ont changé de métier, les autres étant écoliers ou femmes de ménage. Des 12 patients qui étaient des sportifs actifs, 9 ne peuvent plus l'être.

III. Conclusion finale.

L'analyse de la laxité du genou est un élément essentiel du diagnostic des dérangements internes.
Un diagnostic aussi complet que possible est le début d'une thérapie adequate.

Literature

Barth — Zur frage des „Schnellende Kniees". Monatschr. f. Unfallheilk. Leips - 1897 - i.v. 213.

Bousquet, G. — Le diagnostic des laxités chroniques du genou. Rev. de Chir. Orth. Tome 58, Suppl. I p. 61 (1972).

Braune, W., Fischer, O. — Uber den Schwerpunkt des menslichen Körpers. Abhandl. d. Math.-Phys. Cl. d. k. Sächs. Gesellsch. Wissensch. 15, 561 (1889).

Braune, W., Fischer, O. — Bewegungen des Kniegelenke nach einer neuen Methode an lebenden Menschen gemessen. B handl. d. Math.-Phys. Cl. d. k. Sächs. Gesellsch. Wissensch. 17, 75 (1891).

Burri, C. und Rüter, A. — Bandverletzungen am Knie. Hefte zur Unfallheilkunde 125. Springer Verlag (1975).

Castaing, J., cs — Les conditions de la stabilité passive du genou. Rev. de Chir. Orth. Tome 58 Suppl. I, p. 34 (1972).

Dandy, D.J., Jackson, R.W. — The diagnosis of problems after meniscectomie. J.B.J.S. vol. 57B p 349 (1975).

Dejour, H. — Physio-pathologie des laxités chroniques du genou. Rev. de Chir. Orth. Tome 58, Suppl. I, p. 61 (1972).

Dejour, H. — Les lesions isolées du ligament croisé posterieur. Rev. Chir. Orth. Suppl. II Tome 62 p. 129 (1976).

Eikelaar, H.R. — Arthroscopy of the knee. Proefschrift VRU Groningen 1975.

Felsenreich, F. — Die Röntgendiagnose der veralteten Kreuzbandläsion des Kniegelenkes. Fortschritte auf dem Gebiete der Röntgenstralen Band 49 p 341 (1934).

Felsenreich, F. — Radiologische darstellung pathologischer Beweglichkeit des Kniegelenkes nach Kreuzbandverletzungen. Zentralblatt für Chirurgie no 6 p 320 (1935).

Fick, R. — Handbuch der Anatomie und Mechanik der Gelenke. Jena Verlag von Gustav Fischer (1911).

Fischer, O. — Kinematik organischer Gelenke. Braunschweig (1907).

Frankel, V.H., Burstein, A.H. — Orthopaedic biomechanics. Lea & Fehiger (1970).

Girgis, G. — The Cruciate ligaments of the knee-joint. Clin. Orthop. no. 106, p. 216 (1975).

Helfet, A.J. — Disorders of the knee. J.B. Lippincott Cie. (1974).

Hillen, B. — Enkele functioneel-anatomische gegevens over de gewrichten. Lessen anatomie R.U.G. (1976).

Hoffa, A. — Uber Röntgenbilder nach Sauerstoffeinblazung in das Kniegelenk. Berliner klinische Wochenschrift no 28 p 940 (1906).

Hughston, J.C. — Classification of the knee ligament instability's. J.B.J.S. vol 58 A no. 2, p. 159 (part 1) and p. 173 (part 2), 1976.

Huson, A. — The functional anatomy of the knee-joint: the closed kinematic chain as a model of a knee joint. The knee joint. Excerpta medica 1973.

Jackson, R.W. — The role of arthroscopy in the management of disorders of the knee. J.B.J.S. vol. 54B no. 2 p. 310 (1972).
Jacobsen, K. — Stress Radiographical measurement of the anteroposterior medial knee-joint and lateral stability of the knee-joint. Acts Orth. Scand. 97, 335 (1976).
Jacobsen, K. — Stress Radiographical measurements of post-traumatic knee instability. Acta orthop. scand. 48, p. 301 (1977).

Kaplan, E.B. — Some Aspects of Functional Anatomy of the Human Knee-joint. Clin. Orthop. no 23, p. 18 (1956).
Kennedy, J.C. cs — Medial and anterior instability of the knee. J.B.J.S. vol. 53A, p. 1257 (1971).
Kennedy, J.C. cs — The anatomy and function of the anterior cruciate ligament. J.B.J.S. vol. 56A no. 2, p. 223 (1974).
Kingma, M.J. cs — Nederlands leerboek der Orthopedie. Bohn, Scheltema & Holkema 1977.

Last, R.J. — Some Anatomical Details of the Knee Joint. J.B.J.S. vol. 30B, p. 683 (1948).
Last, R.J. — The Popliteus Muscle and the lateral meniscus. J.B.J.S. vol. 32B, p. 94 (1950).
Liljedahl, S. — Roentgendiagnosis of rupture of anterior cruciate ligament. Acta Radiologica vol. 4 fase 3 p. 225 (1966).
Lindblom, K. — The arthrographic appearance of the ligaments of the knee joint. Acta Radiologica 18, 582 (1938).

Maquet, P.G.S. — Biomechanics of the knee. Springer Verlag (1976).
MacIntosh, D.L. — The anterior cruciate ligament: „over the top" repair, J.B.J.S. 56B, p. 591 (1974).
Menschik, A. — Mechanik des Kniegelenkes. I. Teil Z. Orthop. 112, 481 (1974).
Menschik, A. — Mechanik des Kniegelenkes. II. Teil Z. Orthop. 113, 388 (1975).
Menschik, A. — Mechanik des Kniegelenkes. III. Teil F. Sailer, Wien (1974).
Morcher, — Lecture on the 7th international symposum on topical problems in Orthopaedic Surgery, Luzertn (1976).
Morrison, J.B. — Bioengineering analysis of force actions transmitted by the knee joint. Biomed. Eng. 3, 164 (1968).
Morrison, J.B. — The mechanics of the knee joint in relation to normal walking. J. Biomech. 3, 561 (1970).

Nicholas, J. — Double-contrast arthrography of the knee. J.B.J.S. vol. 52A no 2 (1970).
Nomina Anatomica — Nomina Anatomica - fourth edition (1977). Excerpta Medica - Amsterdam - Oxford.

O'Connor, R.L. — Arthroscopy in the diagnosis and treatment of acute ligament injuries of the knee. J.B.J.S. vol. 56A no. 2 p 333 (1974).

Palmer, I. — On the injuries to the ligaments of the knee-joint. Acta Chir. scan. vol. 80 suppl. 53 (1938).
Paturet, G. — Traité d'Anatomie Humaine (Tome II). Masson et Cie (1951).
Paul, J.P. — Bioengineering studies of the forces transmitted by joints. In: Biomechanics and Related Bioengineering Topics (Kenedi, R.M. e.d.), p. 369. Oxford: Pergamon Press 1965.

Ricci, A. — Contribution à l'étude de la réparation chirurgicale des laxités ligamentaires du genou. Thèse no. 241 (1974).
Rijnks, J. — Chondropathia patellae. Proefschrift RU Groningen 1976.

Slocum, D.B., Larson, R.L. — Rotatory instability of the knee. J.B.J.S. vol. 50A no. 2 p. 211 (1968).
Smillie, I.S. — Injuries of the knee joint. Churchill Livingstone 4th edition 1973.

Thijn, C.J.P. — Double contrast arthrography in meniscal lesions and patellar chondropathy. Radiol. Clinica 45; 345 (1976).
Thijn, C.J.P. — Arthrography of the knee joint. Springer Verlag - Heidelberg etc. (1979).
Trillat, A. cs — Chirurgie du genou. Simep Editions (1971).

Wang, C.J. — The effects of flexion and rotation on the length patterns of the ligaments of the knee. Biomechanics vol. 6 p. 587 (1973).
Warren, L.F. — The prime Static Stabilizator of the Medial Side of the Knee. J.B.J.S. Vol. 56A, p. 665 (1974).
Watson-Jones, R. — Fractures and Joint Injuries. Livingstone Ltd. 4th edition (1956).
Weber, W., Weber, E. — Mechanik der menslichen Gewerkzeuge Vierter Abschnitt, p. 161. In der Dieterischen Buchhandlung Göttingen (1836).
Wilson, J.N. — Watson Jones Fractures and Injuries. Fifth edition, Churchill Livingstone (1973).
Wirth, C.J., Artmann, M. — Diagnostische Probleme bei frischen und veralteten Kreuzbandverletzungen des Kniegelenkes. Arch. Orthop. Unfall, Chir. 81, 333 (1975).